THE ECONOMIC VALUE OF IMPROVEMENTS IN THE ECOLOGY OF IRISH RIVERS DUE TO THE WATER FRAMEWORK DIRECTIVE

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Mavra Stithou, B.Sc. M.Sc.

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« Ν'αγαπάς την ευθύνη. Να λες, εγώ μονάχος μου έχω χρέος να σώσω την γη. Αν δεν σωθεί, εγώ φταίω»

Νίκος Καζαντζάκης. Ασκητική

"Love responsibility. Say: It is my duty, and mine alone, to save the earth. If it is not saved, then I alone am to blame."

N. Kazantzakis, The Saviors of God; Spiritual Exercises

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 ecological status in catchment management plans, along with the introduction of full social cost pricing for water use. In this thesis, the primary focus is on the use of the Choice Experiment (CE) method. The CE method is reviewed and then used to estimate the value of improvements in a number of components of ecological status on two Irish waterways (the Boyne and the Suir). Apart from CE method another stated preference approach to environmental valuation is also considered; the Contingent Valuation Method (CVM). This thesis determines what value the targeted population of the two catchments place on the non-market economic benefits of moves towards GES by employing both approaches and various model specifications, while the applicability of Benefit Transfer (BT) method is also assessed under different tests. In addition, the design of the questionnaire used in the survey stage of the research, offered the possibility of investigating issues related to the effect of cognitive ability and psychometric factors on choice. Respondents with discontinuous preferences are identified and analysis is conducted to investigate the implications of not accounting for these preferences. Finally, due to experiencing protesting behaviour by a proportion of the sampling population an attempt is made to investigate the parameters that contributed to this inclination.

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ABBREVIATIONS

AIC	Akaike Information Criterion
ASC	Alternative Specific Constant
AVC	Asymptotic Variance - Covariance
BIC	Bayesian Information Criterion
BT	Benefit Transfer
CBA	Cost-Benefit Analysis
CDF	Cumulative Distribution Function
CE	Choice Experiment
CM	Choice Modeling
CS	Compensating Surplus
CVM	Contingent Valuation Method
CV	Compensating Variation
DC	Dichotomous Choice
EDs	Electoral Divisions
EPA	Environmental Protection Agency
ERBD	Eastern River Basin District
ESRI	Economic, Social and Research Institute
EU	European Union
GES	Good Ecological Status
GEV	Generalized Extreme Value
GIS	Geographical Information Systems
HA	Hydrometric Area
HEV	Heteroskedastic Extreme Value (model)
IIA	Independence from Irrelevant Alternatives
IID	Independently and Identically Distributed
IV	Inclusive Value
Km	Kilometre
LCM	Latent Class Model
LL	Log likelihood
LR	Likelihood Ratio
MLE	Maximum Likelihood Estimation

MMNL	Mixed Multinomial Logit
MNL	Multinomial Logit
MS	Member State
NMNL	Nested Multinomial Logit
OECV	Open-Ended Contingent Valuation
PCCV	Payment Card Contingent Valuation
RBD	River Basin District
RPA	Register of Protected Area
RUM	Random Utility Maximization
SAC	Special Areas of Conservation
SERBD	South Eastern River Basin District
SPA	Special Protection Area
SQ	*Status quo*
SRAs	Special Riparian Areas
TCM	Travel Cost Method
TE	Transfer Error
WFD	Water Framework Directive
WTA	Willingness-to-Accept
WTP	Willingness-to-Pay

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INTRODUCTION

1.1 Chapter overview

The Water Framework Directive (WFD) was formulated to address the weaknesses of previous water-related directives by adopting an integrated water management approach. This chapter offers an overview of the WFD (Section 1.2), focusing on the main changes that it brings and places emphasis on the inclusion of economics, which provide the motivation behind this thesis. Section 1.3 presents Ireland's approach to WFD implementation, while the final section (Section 1.4) presents the objectives of the thesis and the specific contribution of each chapter.

1.2 Summary of policy context

1.2.1 General overview of the WFD

It is internationally recognised that water resources are necessary inputs to production in economic sectors such as agriculture (arable and non-arable land, aquaculture, commercial fishing, and forestry), industry (power generation) and tourism, as well as to household consumption (UNEP 2005).

An examination of water policy through previous water directives, including the Nitrates Directive and the Bathing Water Quality Directive, demonstrates how current policy evolved from an emphasis on public health protection to environmental protection and finally, as formed today, to the notions of 'sustainable use' of water and an integrated ecosystem-based approach to water management. What is achieved from these changes is that although in the past EU legislation on water was focused on specific environmental problems related to water quality as far as for example drinking, bathing or freshwater fishing activities are concerned, emphasis is now placed on the improvement of the ecological quality of water and its eco-system functions, by using a broader and integrated approach involving both environmental quality objectives coupled with emission limit values.

The WFD (2000/60) was adopted in October 2000, and it establishes a framework for European Community action in the field of water policy. The aim of the WFD is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and ground waters (CEC 2000). The importance of water is crystallised in the first recital of the Directive. It states that "[W]ater is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such" (CEC 2000, p. I.327/1). The Directive calls for integrated catchment management plans to be prepared for all river basins in order to achieve Good Ecological Status (GES) in all EU waters by 2015. Particularly, according to Article 2 (18), '[G]ood surface water status' refers to the status achieved by a surface water body when both its ecological status and its chemical status are at least 'good'. As such, the Directive aims at achieving a minimum standard of 'good' and 'non-deteriorating' status, and sets common approaches and goals for water management in the EU Member State (MS) countries adopting a broader measure of water quality.

The suggested means to achieve that goal is the planning at the natural hydrologic (river basin) level/unit instead of other administrative or political boundaries and the implementation of pollution-control measures in cases where existing legislation on water quality and pollution is proved inadequate. Hence, an important change in water management policy is that the measures to achieve WFD objectives will be co-ordinated at the level of River Basin District (RBD) that will correspond to large catchment basins incorporating the smaller sub basins. In the case that a basin crosses national boundaries, the responsibility should be shared between governments and one single vision should be created.

For the assessment of quality, three main characteristics are considered. The first is that of biological quality elements. The parameters to be measured for river, lake and transitional waters are composition and abundance of aquatic flora (macrophytes) and benthic fauna (invertebrates) as well as the composition, abundance and age of structure of fish. In the case of the marine environment, instead of the 'fish' parameter the composition, abundance and biomass of phytoplankton is considered.

The other two quality characteristics refer to elements that support biological elements. One is the physico-chemical elements such as condition of thermal, oxygen, salinity, acid, nutrient and transparency, and the other is hydromorphological elements that can include in the case of a river for example, the quantity and dynamics of water flow, its continuity, depth and width variation, and structure of the riparian zone.

The Directive's goal is diversified in the case of 'artificial/modified' waters serving economic activities where the GES turns to 'good ecological potential' and in the case of 'protected zones' (*i.e.,* areas designed for the protection of habitats or species) and nutrient sensitive areas where more stringent requirements may be applied. For its implementation, the Directive calls for the authority of each RBD to prepare and put into action a six year River Basin Management Plan that will include a description of the district's characteristics, the identification of protected areas, the impact and pressures of human activity on water status (point source and diffuse pollution, abstraction and land-use patterns), an economic analysis of the cost of the water, an estimation of the effects of existing legislation to achieve the objectives, and information on measures taken to achieve goals. In implementing the measures, MS are asked 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. At this stage, according to Article 14, public participation of all interested parties should contribute to the identification of measures to be adopted.

It should be noted that in this context, monitoring is central to the Directive and according to Article 8 includes several monitoring requirements, not only to determine the classification of waters' status but also to continue assessing the necessity for additional measures or ensure that mitigation measures are implemented. Thus, the main steps that the WFD involves could be summarised in the setting of ecological standards, the identification of anthropogenic pressures, and the adoption of corrective measures. Furthermore, the main change that the Directive brings is that it institutionalises the ecosystem objectives and has, to some extent, a binding character. For each MS there is a common implementation strategy and timetable as summarised in the following table (Table 1.1).

Table 1.1: WFD timetable

Year	Issue	Reference
2000	Directive entered into force	Art. 25
2003	Transposition in national legislation Identification of RBDs and Authorities	Art. 23 Art. 3
2004	Characterisation of river basin: pressures, impacts and economic analysis	Art. 5
2006	Establishment of monitoring network Start public consultation (at the latest)	Art. 8 Art. 14
2008	Present draft river basin management plan	Art. 13
2009	Finalise river basin management plan including programme of measures	Art. 13 & 11
2010	Introduce pricing policies	Art. 9
2012	Make operational programmes of measures	Art. 11
2015	Meet environmental objectives	Art. 4
2021	First management cycle ends	Art. 4 & 13
2027	Second management cycle ends, final deadline for meeting objectives	Art. 4 & 13

Source: http://ec.europa.eu/environment/water/water-framework/info/timetable_en.htm

1.2.2 Economics of the WFD and implications

From an economic perspective, water resources are not efficiently allocated and may be overexploited due, to some degree, to the existence of market and government failures at different levels (local, national, international). This phenomenon primarily occurs because of the public good nature of water resources and secondly because of the complexity that characterises water value (including use and non-use values), that does not allow it to be traded in markets as private goods. Brouwer *et al.* (2009, p.13) argue that the main problem when considering economic choices related to water is that a competitive, freely functioning market does not exist for many water related uses because "water is an essential commodity such that the value for a basic survival amount is infinite; water has natural monopoly characteristics; property rights for water resources are often absent and difficult to define; water is a 'bulky' commodity, thereby restricting the development of markets beyond the local area".

As economic efficiency occurs at the point where net social benefits of an economic activity are maximised, or equivalently, when the marginal benefits are equal to marginal costs, in order to implement the most efficient social and economic policies that prevent the excessive degradation and depletion of environmental resources it is necessary to establish their full value, and to incorporate this into private and public decision-making processes (Birol *et al.*, 2006). The WFD is targeted in this direction in order to correct for 'market or government failures' since MS will have to challenge shortfalls of relevant institutions so as to achieve the Directive's objectives.

In particular, the EU WFD is one of the policy initiatives that aim to ensure the sustainable management and conservation of this valuable resource, along with other international efforts such as the 1971 Ramsar Convention on Wetlands of International Importance (Ramsar 1996). In order to achieve this, the WFD promotes the concept of water as an economic commodity, while maintaining its focus on its broader and often intangible value. However, given the different characteristics of demand for different uses of this resource related to location, quality, quantity and timing, any consideration of water as an economic good needs to ensure its commensurability in terms of a common denominator of place, form and time (Brouwer *et al.*, 2009).

The Directive recognises the importance of economics by integrating it in different ways in order to guide decisions that are in line with the objectives of the Directive. Particularly, economic principles are to be applied in four main areas within a river basin context (Morris 2004, p.4):

- The estimation of the demand for water and the valuation of water in its alternative uses (Article 5)
- The identification and recovery of costs, environmental and resource, associated with water services, having regard for the polluter pays principle and the efficient use of water (Article 9)
- The use of economic appraisal methods to guide water resource management decisions (Article 11)
- The use of economic instruments to achieve the objectives of the WFD, including the use of incentive pricing and market mechanisms (Article 11)

Specifically, Article 9 stresses the need for users (that is industries, farmers, and households) to be charged a price that reflects the full cost of the water services they receive. Full cost pricing is a mandatory part of the river management plan and according to the Directive's timetable, MS should have introduced water pricing policies by 2010. In the case of Ireland, domestic water service charges were abolished at the start of 1997 as the need for reform became necessary because of the diversity of the charging regime, the unaddressed difficulties it posed to some families, and the absence of incentives for the careful use of water (Scott and Lawlor, 1997). As a result, Irish Government policy and national legislation prohibited direct charges for domestic use and local authorities covered their expenditure in relation to the provision of these services through funding from the General Purposes Payments from central funds. However, this policy has been recently reconsidered and Budget 2010 indicated that a system of water metering for homes will be introduced and water charges will be based on the amount consumed above a free allocation.

As previously mentioned, at MS level the Directive introduces the principle of economic analysis in water management (Article 5). The economic analysis is expected to provide room for derogations under the umbrella of disproportionate costs. With regard to the latter concept, Article 4 states that exemptions are possible if the cost of reaching the GES is disproportionate[1]. However, in order to evaluate the extent to which this is the case and to assess 'disproportionality', one also has to know the costs and benefits associated with reaching environmental objectives, in both qualitative and quantitative terms. In order to pass the test, costs should exceed benefits by a significant margin in a cost-benefit framework.

[1]Costs are considered as disproportionate if they exceed the monetised benefits of achieving 'good status' in a water body.

Hence, the tool kit of economic analysis includes the estimation of both direct and indirect costs and benefits to be considered in each management plan (Hanley and Black, 2006). Regarding the nature of benefits, economic analysis will consider direct benefits such as reductions in the cost of drinking water treatment downstream when less pollution is discharged into a river and indirect benefits such as an increase in jobs if cleaner coastal waters lead to higher tourism levels. Furthermore, more difficult to quantify benefits, such as recreation and availability of healthy ecosystems, will also be included. It is regarded that the contribution of valuation methods can be useful in that respect. In general, this is an important but difficult task for river basin authorities, and it will involve them having to consider and evaluate costs and benefits - including environmental criteria. Hence, the concept of environmental and resource costs and benefits plays an important role in the economic analysis of the Directive and practical guidelines for their assessment have been developed (European Communities, 2002, Brouwer *et al.*, 2009).

In general, economics and their subset of environmental economics are expected to play an important and supportive role in WFD implementation (through Articles 9, 11 and 4), and in particular in justifying spending on environmental protection where applicable. Particularly focusing on the contribution of the valuation of benefits, which is this thesis' concern, it is regarded that their inclusion will facilitate water-related decision-making in different ways.

1.2.3 Criticism

According to Kallis and Butler (2001) the main strengths of the Directive apart from the broader and integrated ecosystem approach is that it introduces changes with respect to institutions, planning and information processes, and the 'user-pays' approach, but importantly sets a concrete standard of no further deterioration for any water.

At the same time, serious concerns about the success of the Directive have been expressed. For example, the WFD requires that charges for water services should adopt the principle of full cost recovery in accordance with the polluter pays principle in order to provide incentives for water use efficiency. However, it is expected to be quite challenging in a number of MS that water in the domestic and agricultural sectors is subsidised (Spain, Greece, and Portugal) or water pricing is completely absent (Ireland). In the latter case, the political cost of asking households to pay for environmental improvements when sources of diffuse pollution are not fully checked is expected to be high. Furthermore, pricing mechanisms imply 'benefit pricing' based on willingness to pay and there is a fear of discriminatory practices from the side of profit seeking suppliers (Morris 2004).

Regarding assessment of "disproportionality", it has been argued that whether or not costs are considered disproportionate is highly arbitrary and subjective (European Communities, 2002; Brouwer 2008) as it remains to be answered (i) what is an acceptable cost level in relation to the expected environmental benefits for example, being a maximum of two, three or four times the expected (monetary) benefits; and (ii) what is the acceptability of this decision to those who bear the financial burden (Brouwer 2008). It has been also noted that it is highly questionable whether policy makers and society as a whole are willing to pay the relevant investment sums without any further justification as to their socio-economic benefits (Brouwer 2008), while Brouwer and Pearce (2005) argue that European legislation such as the WFD introduces 'asymmetric property rights' assigning higher weights to environmental benefits compared to the social costs involved.

Kallis and Butler (2001) express a fear that ambiguity of terms especially related to derogations coupled with the high costs involved and the lack of a clear-cut legal mandate to achieve the status objectives may undermine the effectiveness of the policy as unwilling MS may exploit legislative loopholes to avoid implementation. Finally, Carter and Howe (2006) argue that the WFD is an ambitious piece of legislation and its key objective to achieve good water status in most of Europe's waters is not expected to be achieved in the short term (by 2015).

1.3 Ireland's implementation

1.3.1 A general overview

According to the Environmental Protection Agency (EPA), approximately 50% of the land area of the State is drained by nine river systems. In Ireland, there are five River RBDs, as presented in Figure 1.1, wholly within the State. These are the Eastern, the South Eastern, the North Eastern, the Western, and the South Western. The Shannon, Neagh-Bann and North Western RBDs are shared with Northern Ireland and are thus classified as International RBDs. An important element revealed by this figure is that the RBDs have been designed according to the rivers' boundaries rather than administrative jurisdictions. As a result, it is common that more than one county will fall within a RBD's borders. A further division, not apparent in this figure, is that of Hydrometric Areas (HAs). Ireland is divided into 40 HAs, each of which comprises a single large river catchment or a group of smaller catchments. As a result, the Boyne HA and the Suir HA that are the case study areas of the thesis belong to the Eastern and the South Eastern RBD respectively.

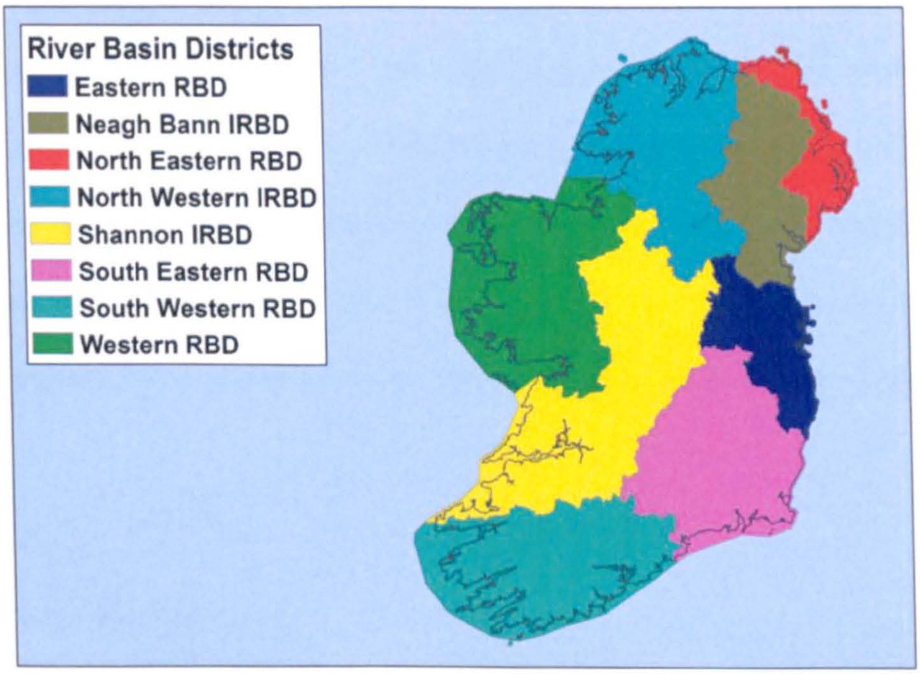

Figure 1.1: River Basin Districts (RBDs) in Ireland

(Source: EPA (2005), Characterisation Report)

Water quality in Ireland is monitored mainly by the EPA and the local authorities, supplemented when needed by the fishery agencies. The EPA assesses the biological quality of the rivers and streams (and to a lesser extent their chemical status) at some 3200 monitoring locations every three years.

Following the National Summary Report (2005), the Q rating/values reported in the following table (Table 1.2) express the Irish river biological status with Q5 representing the highest biological status and Q1 the poorest. Of the five biological elements that comprise river ecological status under the WFD, the Q system takes account of benthic invertebrates and to a degree macrophytes and phytobenthos. The EPA has determined that Q4 status is likely to represent good status. Therefore, for the impact risk assessment, any river water body with a recorded status of Q4 or better is identified as not at risk and protective management measures need to be applied to maintain its status. On the contrary, any river water body with a recorded status of less than Q4 is placed in the 'at risk' category on the basis that it is already impacted and therefore will not achieve the objective of good status without mitigation measures. Furthermore, these biotic indices are related to the four Water Quality Classes (Unpolluted, Slightly Polluted, Moderately Polluted and Seriously Polluted) and the WFD status as shown in Table 1.2.

Table 1.2: Quality classifications

Biotic Index	Quality Status	Quality Class	WFD Status
Q5, Q4-5	Unpolluted	Class A	High
Q4	Unpolluted	Class A	Good
Q3-4	Slight Polluted	Class B	Moderate
Q3, Q2-3	Moderate	Class C	Poor
Q2, Q1-2, Q1	Serious	Class D	Bad

Source: EPA (2008)

Figure 1.2 summarises trends within individual RBDs for unpolluted channels (corresponding to high and GES based on results for the macroinverte-brate quality element) (EPA 2010). Results show that the South-Western and the Western river basin districts continue to be ranked the most unpolluted districts confirming that the less densely populated and less developed regions have the higher proportions of unpolluted channels.

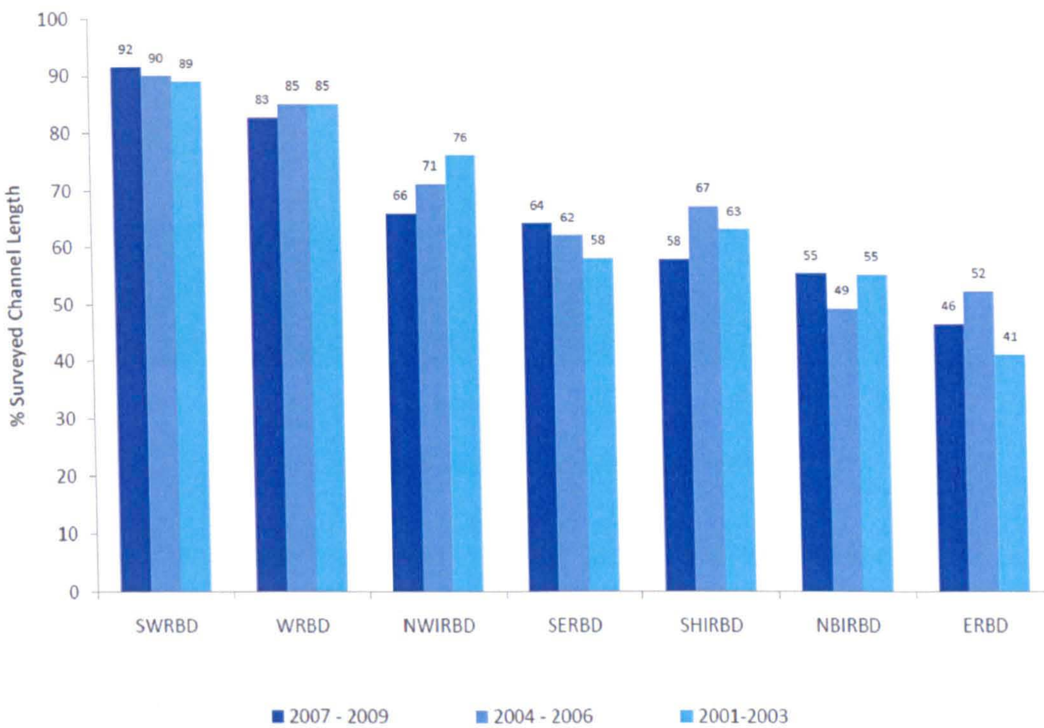

Figure 1.2: Trends in the percentage of unpolluted Class A (High and Good status) channel length in each RBD in the state for the survey periods 2007-2009, 2004-2006 and 2001-2003 (Source: EPA (2010))

Furthermore, the various biological and supporting physico-chemical quality elements are combined within individual river water bodies on a one-out-all-out basis and results are presented in Figure 1.3. Following the EPA (2010) report, the overall ecological status seems lower than that based on individual sites and quality elements.

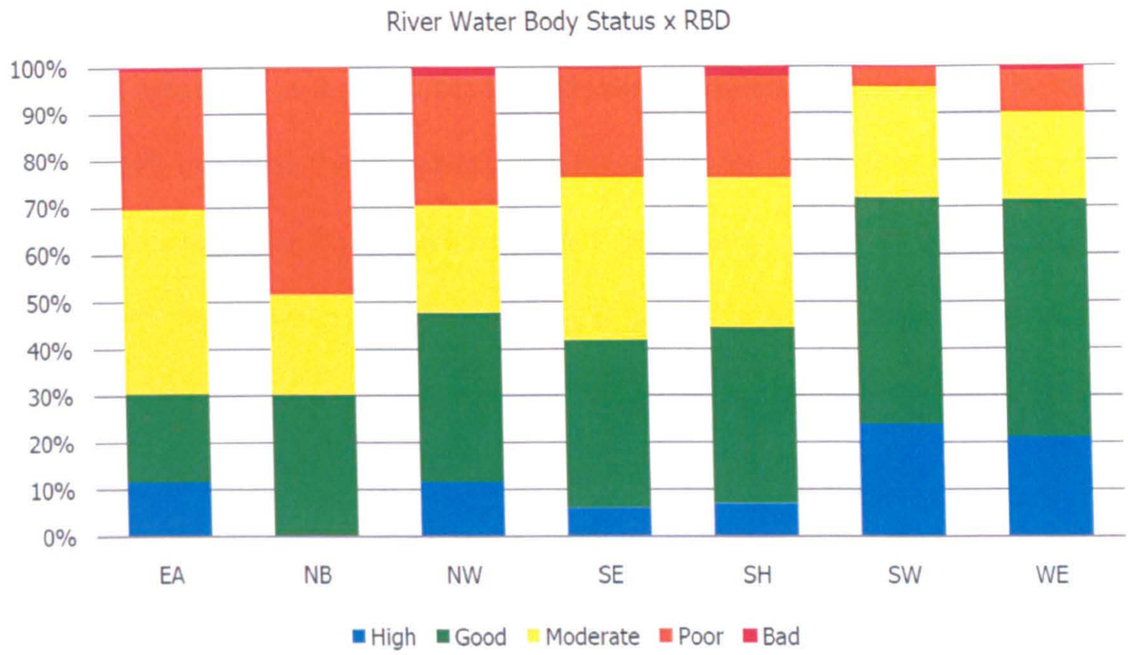

Figure 1.3: Percentage breakdown of river water bodies within each RBD showing final ecological status based on lowest status for the available range of biological and physico-chemical quality elements within each water body (Source: EPA (2010))

Finally, it is noted that the main activities in the implementation of the WFD take place in the context of River Basin Management Projects led by local authorities, while the Department of the Environment, Heritage and Local Government is promoting the establishment by local authorities of such projects to address all inland and coastal waters[2].

1.3.2 Methodology employed for related economic analysis

As explained previously, 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

[2] http://www.wfdireland.ie/

information gaps have been 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 used 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, in-stream use valuations such as recreational fishing, boating, beach visitation, and other water-based leisure use valuations that were based on national estimates of expenditures for using Ireland's recreational fisheries, navigable waters, beaches, and other marine amenities are available from a publication by the Economic and Social Research Institute via the Marine 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".

Other valuations concerned wetlands and Special Riparian Areas (SRAs). The latter included Natural Heritage Areas, Special Protection Areas, and Special Areas of Conservation in Ireland which were collectively deemed SRAs for the purposes of estimating values associated with these areas in the 'Economic Analysis of Water Use in Ireland' report (CDM 2004). The estimates for these values were derived from a literature review of applicable North American and Northern European valuation studies, with geography, demography, and socioeconomics similar to Ireland, as no

Ireland based studies could be identified. The focus of the literature review was on Contingent Valuation Method (CVM) Willingness to Pay (WTP) studies, including in particular a series of wetland valuation studies in England and a series of valuation studies of Environmentally Sensitive Areas in Scotland.

Goodbody (2008) evaluated 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 the UK. It is 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.26).

1.4 Specific aims and outline of the thesis

1.4.1 Overall outline and contribution of the thesis

By responding to the urgent policy requirement to value the non-market economic benefits of WFD implementation, the main issue that this thesis explores is the valuation of improvements in a number of components of ecological status of two Irish waterways (the Boyne and the Suir), in accordance with Article 9(1) of the Directive, by applying the Choice Experiment (CE) method. CEs are an example of the stated preference approach to environmental valuation, and they involve eliciting responses from individuals in constructed, hypothetical markets, rather than the study of actual behaviour. In a CE setting, environmental goods are valued in terms of their attributes by applying probabilistic models to choices between different bundles of attributes.

Individuals are expected to choose to 'consume' the bundle of attributes that gives them higher utility or satisfaction. The decision to use a CE approach was driven by the desire to estimate values for different component parts, or aspects, of water quality, as interpreted by the WFD. These component parts constitute the attributes in the CE design. Although CE is the main valuation method employed, a CVM follow-up question was also included in the survey. There were different reasons that justified its use. Mainly the CVM was used to compare value estimates of GES between the two methods and as a consistency check for CE responses.

Hence, one of the main objectives of this thesis is to value non-market benefits, through stated preference methods, due to the WFD and hence to provide data that are lacking in the case of Ireland. Lawlor *et al.* (2007) emphasised that valuing external benefits (improvements to water quality in rivers) presents a great challenge since data on the numbers of people using the water bodies and how they value any change that occurs are lacking. The authors, acknowledging the lack of benefit estimates in Ireland, urge action and a more systematic approach that includes a programme of economic valuation of main representative types of water and water use, using WTP. It should be noted that this thesis is the first survey in Ireland that deals with the valuation of improvements in rivers' environmental quality. As will be reported in Chapter 2 through the literature review, there are only a handful of studies in Ireland that have employed environmental valuation methods related to rivers' environment.

Furthermore, this study is the only original study in the country that relates valuation of rivers' improvements due to the WFD. As it is confirmed in the National Summary Report (2005), the benefits' estimations needed to conduct the Cost-Benefit Analysis

(CBA) are only partially complete at the RBD level, and absent at the water body or river segment level. It is regarded that this study could contribute towards this knowledge gap and provide benefit estimates that can be used in a CBA context, but also contribute to the information base that is ultimately needed to analyse water pricing policies pursuant to the WFD 'user pays' principle. In addition, it is expected that this study will reveal the incentive for the public to maintain or achieve GES for water bodies, and as such may provide useful information even outside of WFD reporting requirements.

According to Bateman *et al.* (2006a, p. 222), "the economic benefits (of implementing the WFD) are likely to be many although only a minority are likely to be easily amendable to quantification, for example, reduced water treatment costs. One important motivation for the WFD appears to be the creation of non-market environmental benefits, such as open-access recreation". In addition, the authors refer to non-use benefits such as "values individuals may hold for improvements in wildlife habitat which are not incorporated within recreation and amenity values" (Bateman *et al.*, 2006a, p.227).

Furthermore, the research design of the survey and in particular the sampling of two distant catchment areas offers the possibility for cross-comparisons of the same river improvements within the country and explores how the two samples performed in the same task. Hence, differences between the sampling population regarding their attitudes and characteristics to suggested improvements in river's environment and therefore to elicited WTP values are highlighted in this context, pointing out as well the challenges that a potential Benefit Transfer (BT) would entail. In addition, in each of the case-study catchments the same questionnaire design is employed including two different sets of choice tasks to be used in each questionnaire.

The first set of choice tasks presents respondents with environmental improvements that concerned only the local river. The second set presents respondents with environmental attributes corresponding to river improvements and an extra attribute that corresponds to the river where improvements will take place. In this context, the respondent trades-off improvements between rivers. That research design, incorporating geographical scale as an attribute, gives the opportunity to explore how the two samples performed under the two choice frames and investigates the issues of sensitivity to scope. In addition, the rationale for obtaining out-of-catchment values is related to the fact that respondents who do not reside within a catchment may, nevertheless, value improved catchment quality (Morrison and Bennett, 2004). Hence, it will be interesting to distinguish whether non-use out-of-catchment values are higher for the Boyne considering its nationally symbolic character and that the values for such a culturally significant river may in principle be held by anyone.

In addition, the research design offers the possibility to explore if individual values of GES derived from the CE add up to the total value of a CVM framework. Furthermore, the design makes it possible to investigate the performance of the theses methods in a BT framework. Finally, specific issues of behavioural theory such as that of respondents' cognitive ability, adopted decision rules, and how these interact with preference formation are investigated by making use of information derived in follow-up questions. The existence of discontinuous preferences is also in the research agenda of this thesis. The following table (Table 1.3) presents the thesis' expectations, as these were set from the beginning, from a policy and a methodology perspective, as well as secondary expectations that resulted from data analysis.

Table 1.3: Thesis' expectations

Primary expectations	*Contribution*
• Elicit values of GES of two rivers in Ireland using CE and CVM	There is no study done in Ireland
• Explore differences in elicited values of same improvements between catchments and the potential of BT method	Previously done but it is expected to fill in gaps and highlight challenges regarding BT's potential in WFD implementation in Ireland
• Test for sensitivity to choice framing	Not many studies in a CE context. Research design involves two rivers and two sets of choice cards within each sample. First set of choice cards involves improvements only in the local river, second set includes location variable as extra attribute
• Test for sensitivity to geographic scope	Not many studies in a CE context. Comparisons of values are attempted between the local river and the other river or combination of both. Hence, the second set of cards makes possible out-of catchment and in-site catchment value comparisons
• Explore the degree of cognitive ability and other psychometric factors involved in CE and their impact on choice	Not fully explored in the literature
• Explore the existence of discontinuous preferences	Add to existing literature
• Compare CE results to Payment Card Contingent Valuation (PCCV) method	Add to existing literature
• Compare CE and PCCV performance in BT	Add to existing literature
Secondary expectations	*Contribution*
• Protester analysis in a CE framework	Not fully explored in the literature of CE
• Sensitivity of welfare estimates to *status quo* effect	Add to existing literature

• Explore the impact of cognitive ability on welfare estimates and BT	Not fully explored in the literature
• Explore the impact of other psychometric variables on WTP	Not fully explored in the literature

More particularly, the specific objectives that each chapter deals with are presented next.

1.4.2 Specific contribution of thesis's chapters

Chapter 2

Chapter 2 presents a literature review on river water quality. It should be noted that as the literature on this particular issue is extensive, the aim of the chapter is to present a part of the latest studies motivated by the Directive without covering all studies as more and more are currently being realised. The chapter starts with a presentation of CVM studies that have been used in river water quality valuation, providing some examples from the literature. Then the literature review focuses on studies that have employed CEs to value river water quality and on studies that have employed CEs in the context of the WFD.

Chapter 3

The thesis' applied method of discrete CE for deriving welfare estimates for rivers' improvements due to the WFD is presented in this chapter. Hence, the focus of Chapter 3 is the theoretical and econometric background information of the discrete CE methodology. In particular, the chapter provides an overview of the methodology starting from the first steps of its development to recent advances in the field. Furthermore, this chapter provides a point of reference for the analysis of data in subsequent chapters. It starts by explaining how the method evolved from the economic concept to the econometric model and its estimation. Then the discrete choice models employed for CE data analysis are presented, starting from the Multinomial Logit Model (MNL).

Chapter 4

Chapter 4 aims at reporting the main stages and decisions that were taken while developing the questionnaire and designing the survey. Primarily, the case study rivers are introduced by presenting their main characteristics and justifying the choice made from other rivers. Then the chapter evolves to the design of the valuation framework focusing on the selection of attributes and their corresponding levels to be used in the CE. Special emphasis is given to the importance and contribution of consultation with experts and the contact of focus groups in the respective catchment areas. Then the main elements of the questionnaire are presented. An important section of this chapter is assigned to explain the experimental design employed. In the final part of Chapter 4, specific decisions related to survey issues are presented.

Chapter 5

Analysis of data from the two surveys begins in Chapter 5. The objective of this chapter is to describe the samples by presenting the profile of respondents with regard to different aspects of the survey, such as their reaction to choice cards, their socio-economic characteristics, environmental attitudes, and awareness regarding the rivers, as well as psychometric characteristics. Descriptive statistics concern positive bidders, original zero bidders and protesters. The non-negligible number of respondents who opted for the No Change option, and in particular protesters, the opportunity for a protester analysis. In particular, an attempt is made to investigate the determinants of this behaviour in a CE context.

Chapter 6

Chapter 6 aims at providing an overview of the main findings arising from the catchment surveys and a preliminary analysis of the discrete CEs. Findings from the surveys are intended to show that there is a wide range in residents' opinion and attitudes with regard to river improvements. Differences are revealed not only within catchments but also between catchments. A key objective of Chapter 6 is to compare model performance and model outputs from discrete choice models under a number of alternative specifications that relax primary assumptions and include additional variables. A sensitivity analysis focusing on the Boyne sample attempts to show that different underlying econometric assumptions play a crucial role in modelling outcomes, while more sophisticated discrete choice models outperform basic models.

The last section of the chapter presents an attempt to apply the BT method. The employed BT tests include equality of model parameters, implicit prices, and Compensating Surplus (CS). This section seeks to explore the challenges that a BT test entails and its policy implications in the context of the Directive. The last section of the chapter explains the difficulties and different approaches that were employed in analysing data from the second set of cards.

Chapter 7

Findings from the CVM tasks are reported in Chapter 7. This short chapter involves a description of respondents' profile to the CVM task and aims to determine the factors that explain payment card chosen bids. Then derived WTP estimates of GES offer the possibility for comparisons between the two valuation methods considering different specifications. Finally, a brief assessment of CVM's applicability for BT is also offered.

Chapter 8

In Chapter 8, this thesis attempts to explore the impact of psychometric variables in preference formation. Information on these variables is provided by follow-up questions within the survey. Firstly, the issue of cognitive burden is investigated by using a constructed continuous variable. Then the focus is on rules that underlie choices that may be contrary or complementary to the dominant utility maximization. The last section presents findings from responses regarding the existence of discontinuous preferences.

Chapter 9

Chapter 9, apart from criticising the weaknesses of the survey, aims to integrate the main findings arising from the analysis of discrete choice experiments, with CVM and

BT application. The main objective of the chapter is to summarise the main conclusions and provide policy and methodology recommendations arising from the study.

2

LITERATURE REVIEW OF VALUATION STUDIES ON RIVER QUALITY IMPROVEMENTS

2.1 Introduction

This chapter focuses on empirical studies that have faced the challenge of valuing environmental improvements, mainly in rivers systems, over the last years. The review is by no means exhaustive as the number of these studies is constantly increasing, especially since the ratification and subsequent start of the WFD. Although the emphasis is on the European geographical area, studies from other parts of the world closely related to the objective of the thesis and its special issues are also reported.

In Section 2.2, this chapter begins by outlining the different methodologies that have been employed to value water resources. Within this framework, the weight of the chapter is on stated preference studies. Presenting initially CVM applications in the field, the focus will then turn to CE studies that have been employed to value river quality improvements as this is the main employed methodology of this thesis. More particularly, the emphasis is on the attributes and levels that have been considered by researchers in their attempts to value improvements using CE methodology. The focus is further narrowed down to studies that make use of CE in the context of WFD implementation in order to point out similarities and differences to this thesis' approach. In addition, the literature review in this chapter was used as feedback to inform the selection of attributes and levels as presented in Chapter 4, where the CE questionnaire is described. Section 2.3 summarises the studies that have taken place in Ireland with regard to the valuation of river and water resources. Finally, a brief summary of this chapter is given in Section 2.4.

2.2 Literature review on the stated preference methods used to value water resources with an emphasis on river quality improvements

Due to the special nature of liquid and its mobility trait, water is categorised as a 'high-exclusion cost' resource. Furthermore, the lack of property rights makes water a low-valued commodity. Young (2005) distinguishes between the commodity and environmental benefits derived from water, while he also notes that estimating the economic values and benefits of water-related policies is not an easy task. Valuation results depend on which specific water services are being valued, as well as where and why the valuation exercise is being conducted. In practical terms, valuation of water quality is a complex multidimensional task that involves quality being measured along with several distinct but correlated dimensions (Magat *et al.*, 2000).

Stated preference methods overcome specific limitations of TCM (Travel Cost Method) and Hedonic Pricing as they are capable of measuring both use (recreational fishing) and non-use values (improved water quality). As a result, in the case of water resources that produce a number of services non-traded in markets, stated preference methods that induce individuals to express preferences through WTP, have an advantage over revealed methods in determining the value of economic benefits.

2.2.1 The CVM paradigm

CVM is a popular stated preference method despite the weaknesses embedded in its value elicitation framework. In particular, there are a large number of CVM studies that have examined the issue of river water quality and quantity. As presented in the next paragraphs, examples of characteristics employed to define river water quality and river environment in general are conditions of water flow, loss of naturalness caused by hydromorphological interventions, pollution related to water clarity and eutrophication, and river banks condition.

Although a considerable proportion of CVM literature deals with wetlands' valuation, a large number of studies have focused on the quality of rivers. Loomis *et al.* (2000) explored the Total Economic Value of improvements in an impaired river basin while numerous CVM studies have estimated WTP values for changes in river quality that have improved recreation (Desvousges *et al.*, 1987; Green and Tunstall, 1991; Willis and Garrod, 1991; Roe *et al.*, 1996; Rollins and Wistowsky, 1997; Appelblad, 2001). Studies have also used CVM to value in-stream river sports and water flow conditions (Daubert and Young, 1981; Boyle *et al.*, 1993; Willis and Garrod, 1995; Garrod and Willis, 1996) as well as angling and water flow levels (Willis and Garrod, 1999). In a broader context, Hanley *et al.* (2003) used CVM to value the benefits of improving low-flow conditions on the River Mimram in Southern England.

CVM studies regarding conservation of rivers against the development of hydroelectric power plants have also been applied. Two examples come from Norway (Hervik *et al.*, 1987) and Sweden (Gullberg and Nilsson, 1997). Other aspects of water quality are related to the impact of excess nutrients on rivers' quality. Bateman *et al.* (2006b) conducted a CVM of household WTP to reduce eutrophication impacts in the rivers and lakes in East Anglia, UK, while Silvander and Drake (1989) studied eutrophication effects of nitrogen loads to aquatic systems with respect to a fishery in Sweden. Another more recent CVM study (Thomas and Blakemore, 2007) elicited WTP of anglers for river restoration (fencing and coppicing) in Wales. They estimated farmers' Willingness-to-Accept (WTA) compensation for habitat restoration that would be beneficial to salmonids even though it may have reduced agricultural output. A similar study is that of Amigues *et al.* (2002), who surveyed the WTP of households in the general catchment area of the Garonne River in France. In this case, the authors estimated the WTA compensation of landowners who would have to surrender land for creating a strip of riparian land for habitat restoration.

Instead of examining improvements in water quality, Ruijgrok and Nillesen (2004) focused on the value of another attribute of rivers' environment - that of natural banks in the Netherlands. In the USA, Holmes *et al.* (2004) estimated the benefits of riparian restoration to local households. Another strand of studies focused on the urban stretches of the rivers or the downstream and coastal impact of degraded river systems. In particular, Ozdemiroglu *et al.* (2004) elicited the public's preferences through CVM and CE for reductions in the environmental impacts of sewer overflow discharges to the tidal Thames, while two CVM studies, one in Greece (Kontogianni *et al.*, 2005) and the other in Sweden (Frykblom *et al.*, 2005), valued quality changes in river systems that affect mainly recreation in coastal waters in Thessaloniki's Bay and Stockholm's archipelago respectively.

Other studies have focused on river water quality due to a specific policy. For example, a study initiated by Carson and Mitchell (1993) examined the Clean Water Act in the USA. The focus of this Act was aimed at increasing river water quality at a national level. Furthermore, Baker *et al.* (2007) used CVM along with CE to value improvements in water quality in the whole water environment, including rivers, in England and Wales due to the WFD. Another approach related to the valuation of water quality in the context of the WFD was that of Spash *et al.* (2009). The authors employed CVM to value improvements to biodiversity in the Tummel catchment in the Grampian Highlands of Scotland for achieving the goal of "*Good Ecological Potential*". Brouwer (2006) used CVM in order to examine public preferences and values for bathing water quality improvements in coastal and inland waters, and associated health risks in the Netherlands in the context of the EU Bathing Water Directive. In addition, the European Urban Waste Water Directive motivated Kontogianni's *et al.* (2005) CVM study in Greece. Subsection 2.2.2 focuses more on CE studies, while Subsection 2.2.3 refers to CE studies initiated in light of the WFD.

2.2.2 The CE paradigm

CE method has been employed to estimate both use and non-use values and has gained popularity in recent years among environmental economists. Although the literature demonstrates a vivid interest in the use of CE for valuing wetlands (Morrison *et al.*, 1999b; Carlsson *et al.*, 2003; Othman *et al.*, 2004) a considerable number of CE studies with an emphasis on river quality improvements have been also conducted, as demonstrated in Table 2.1. It should be noted that Adamowicz *et al.* (1994) is the first study to apply CE to non-market valuation. The authors valued sites of water based recreation that were characterised by attributes such as terrain, fish size, fish catch rate, water quality, facilities, swimming, beach, distance from home, water feature (river, stream), fish species, and boating.

Table 2.1: CE studies on river quality improvements

Study	Country	Attributes	Levels
Kragt and Bennett (2009)	Australia	(i) Native river side vegetation (ii) Rare native animal and plant species (iii) Seagrass area (iv) One-off levy on rates collected by the Tasmanian Government	(i) Kilometres (ii) Number of species present (iii) Hectares (iv) $A 0, 30, 60, 200, 400 or 0, 50 , 100, 300, 600
Bennett *et al.* (2006)	Australia	(i) Fish species and populations (ii) River's length with healthy vegetation on both banks (iii) Native water bird and animal species with sustainable populations (iv) River suitable for primary contact recreation without threat to public health (v) Compulsory one-off payment to trust fund	(i) % of species (ii) & (iv) % of river adapted to the background environment of each of the three rivers considered (iii) Number of species (v) $A 0, 20, 50, 200
Morrison and Bennett (2004)	Australia	(i) Recreational uses (across entire river) (ii) Healthy riverside vegetation and wetlands (iii) Native fish (iv) Water birds and other fauna	(i) Different groups of activities present (ii) Along % of the river (iii) & (iv) Number of native fish species present (v) No extra cost, $A 50,

		(v) Levy on water rates (one-off)	100, 200
Ozdemiroglu *et al.* (2004)[a]	UK	(i) Sewage litter (ii) Other litter (iii) Health risk for contacting water sports (iv) Fish population (v) Additional water bill payment (annual increase)	(i) % of total litter (ii) Present or not (iii) No. of days when the health risk is high in a year (iv) No. of times in a year of potential fish kills (v) £0, 5, 15, 23, 36, 45, 77, 115
Van Bueren and Bennett (2004)[b]	Australia	(i) Species protected (ii) Farmland repaired or bush protected (iii) Waterways restored for fishing or swimming (iv) People leaving country areas every year (v) Annual household levy	Levels for national CE: (i) No. of species protected (ii) Millions of hectares rehabilitated (iii) No. of km (iv) No. of people leaving annually (v) $A 0, 20 to 200
Robinson *et al.* (2002)	Australia	(i) Riparian vegetation (ii) Aquatic vegetation (iii) Good or very good appearance (iv) Additional levy on council rates (per year)	(i) to (iii): % of river length (iv) Among others $A 0, 40, 60
Sundqvist (2002)[c]	Sweden	(i) Downstream water level (ii) Erosion and vegetation (iii) Fish life (iv) Increase in electricity price per kWh	(i) Different levels of water flow (ii) Different % of lower erosion and damage to beach adjacent vegetation (iii) May be harmful to some fish species Adapted to migratory fish species such as the salmon Adapted to all inhabitant species (iv) 5, 10, 15, 20 and 25 öre per kWh
Heberling *et al.* (2000)	USA	(i) Uses of stream (ii) River restored (iii) Travel time from home to site (iv) Easy access points (v) Increased water bill payments per year (for next 10 years)	(i) "drinkable, fishable and swimmable" (ii) Miles (iii) 10min, 30min, 2hs (iv) "limited", "excellent" (v) $ 5, 30, 100, 250, 500, 750

[a]This study focused on the urban stretch of the river and sought to elicit the public's preferences for reductions in the environmental impacts of premature combined sewer overflow discharges to the tidal Thames. [b]The policy setting in this study was land and water degradation. [c]This study estimated how environmental impacts arising from hydroelectric production were perceived and valued by non-residential electricity consumers (private and public enterprises).

Another study that is more related to water management issues of a catchment is that of Burton *et al.* (2007). The authors used CE to elicit WTP in order to avoid damage to the natural environment, as well as to avoid the risk of flooding of residents of rural towns and Perth in Australia for managing the Moore catchment. The attributes considered were the area of land under salt and trees, ecological risks to off-farm wetlands and risk of flooding, farm incomes, and personal financial contributions to a management fund.

2.2.3 The CE paradigm with regard to the WFD

Table 2.2, although not totally inclusive summarises some of the studies, whose number is increasing, that have applied the CE technique in the context of valuing economic benefits that derive from WFD implementation. As will be noted, these studies vary in terms of their purpose[3], the geographic scale (local, regional, or national) and hence the affected population. They also vary in terms of the good, the baseline, the change, 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 is approached, since there is no specific guideline from the EU on how to proceed.

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

Table 2.2: CE studies on river quality improvements due to the WFD

Study	Country	Attributes	Levels
Brouwer *et al.* (2010)	Spain	(i)-(iv) Attributes are defined as sub basin areas/zones in which the environmental change occurs (v) Cost price over and above the current water bill	(i) Water quality levels are defined in terms of water use and risks to people and environment (poor, moderate, good, very good): Zone 1: 2 levels of water quality Zone 2: 3 levels of water quality Zone 3: 4 levels of water quality Zone 4: 3 levels of water quality (v) €0 and 6 positive bids from €10 to 150
Poirier and Fleuret (2010)	France	(i)-(iv) Attributes are defined as components of the river basin: coastline, River Touques, River Dives, River Vie (spatial/site specific attributes) (v) Annual voluntary contribution	(i)-(iv) Two levels for each attribute: *status quo* level and good level (v) €0, 10, 20, 30, 40
Kataria *et al.* (2009)	Denmark	<u>*Version 1*</u>: (i)-(iii) Three attributes related to the geographical stretches of the river (iv) Cost: annual water bill per household <u>*Version 2*</u>: (i) Water quality (ii) Angling (iii) Access (iv) Surrounding areas (v) Cost: annual water bill per household	<u>*Version 1:*</u> (i)-(iii) The water quality levels represent the attribute levels and are one of three colours: yellow, green, or blue, referring to the water qualities moderate, good, and very good, respectively of a water ladder* <u>*Version 2:*</u> (i) Blue, green or yellow (water ladder) (ii) Good, improved (iii) Restricted, good (iv) Cultivated agricultural land or non-cultivated *e.g.* wetlands, meadows, *etc.*6 levels for annual water bill per household (both versions) **Water quality ladder*: Four levels of quality in terms of conditions for fish and plants, the potential for using the river for fishing (coarse and game fishing) as well as for bathing, boating, and bird watching
Kataria (2009)	Sweden	(i) Fish (ii) Birds (iii) Benthic invertebrates (iv) River margin vegetation and erosion (v) Additional annual cost for the household	(i) % increase of fish stock (ii) Improved conditions for birds' life: Yes, No (iii) Species richness: High, Moderate, Considerably reduced (iv) Broad to narrow beach combined with various degrees of plant species and biomass growth (3 levels) (v) 0, 200, 375, 600, 850, 1175, 1400

			SEK
Baker *et al.* (2007)	England, Wales	(i) Status of local area in 8 years time (ii) Status of England and Wales in 8 years time (iii) Status of England and Wales and local area in 20 years time (iv) Increase in water bill and other household payments	(i) Different combinations of % of low, medium and high quality in local area at time=0 (current conditions) and at time=8 (in 2015) (ii) Different combinations of % of low, medium and high quality in national area at time=0 (current conditions) and at time=8 (in 2015) (iii) 95, 75 (iv) £0,5,10,20,30,50,100,200
Álvarez-Farizo *et al.* (2007)	Spain	(i) River Ecology (variety of aquatic plants, fish and birds) (ii) Surroundings of the river (litter, smell, visual quality of water, riverside vegetation, erosion) (iii) Supplies of water for urban and agricultural purposes (iv) Increase in the cost of the monthly shopping basket	(i) High and low diversity (ii) High and low quality (iii) Guaranteed or subject to fluctuations (iv) Increases of €1, 2, 5, 8 and 15
Hanley *et al.* (2007)	England	(i) No. of reaches treated (ii) Bad odour (iii) Ecological condition (fish deaths and invertebrate abundance) (iv) Increase in water bills per year	(i) None, reach 1, reaches 2, 3, and 4 (ii) Days a year (iii) Poor, small improvement, medium, large, and very large improvement (iv) £ 0, 6, 12, 18, 24
Hanley *et al.* (2006a)	England, Scotland	(i) Ecology (salmon, trout and coarse fish, range of water plants, insects and birds) (ii)Aesthetics/appearance (sewage or litter) (iii) River banks (trees, plants, degree of erosion) (iv) Higher water rates payments by households to the local sewerage operator	(i)-(iii) Good and fair level (iv) £ 0, 2, 5, 11, 15, 24
Hanley *et al.* (2006b)	Scotland	(i) No. of agricultural jobs lost or gained in the local area (ii) Visual impact (iii) Ecological condition (mammals, plants, fish, smell) (iv) Increase in council tax per year	(i) No loss no creation, loss of five , loss of two, creation of two (ii) Number of months of low flow condition in the year (iii) Worsening, slight improvement, big improvement (iv) £ 0, 2, 10, 17, 30

An addition to the above table is Lago and Glenk's (2008) CE study conducted in Scotland that is similar to the Baker's *et al.* (2007) approach. Another interesting research project at a European scale, funded under the 6th EU Framework Programme and related to the WFD, is AquaMoney[4]. Its main objective is the economic valuation of environmental and resource costs and benefits of the European WFD. The heart of AquaMoney is 11 case studies from different European countries. Based on these case studies, AquaMoney has developed guidelines for BT. The intention is to give policy makers an overview of the range of values that can arise from water related issues and how the perception of environmental problems differ among countries.

Observing the studies in Table 2.2 it is inferred that there is no common approach to river water quality valuation for the purposes of the WFD implementation. In particular, currently two main strands are noticed. One that adopts a more holistic approach to describe water quality (Baker *et al.*, 2007; Kataria *et al.*, 2009; Brouwer *et al.*, 2010) and another that focuses on the particular characteristics of water quality, trying to identify priorities between different river/water services (Hanley *et al.*, 2006a, 2006b; Álvarez-Farizo *et al.*, 2007; Hanley *et al.*, 2007; Kataria, 2009; Kataria *et al.*, 2009). Hence, the first approach incorporates water quality in the CE as a whole, representing the levels of the experiment while the attributes are represented by the time and/or geographical horizon (local, national level, sub basin zones, River A, River B).

The second approach disaggregates water quality to its elements and includes those as attributes in the experiment, while in some cases like that of Hanley *et al.* (2007), geographic scale is included as an attribute along with river environmental attributes.

[4] Aquamoney research project (2006-2009) http://www.aquamoney.org/sites/content.html

However, even in this case there are differences in the attributes used that reflect the special conditions and traits of each water body. Hence, apart from the ecology parameter that is present in all studies (although differently perceived and conceptualised) there is a wide variety of attributes employed from study to study.

Another difference among studies that value river quality improvements is that it seems that there is not a uniform approach concerning the scale or boundaries of the "good". As a result, there are studies that focus on a specific part of the river, in some cases on its urban stretch (Hanley *et al.*, 2006a), on the main channel of the river only (Kataria *et al.*, 2009), the whole catchment (Hanley *et al.*, 2006b), sub basins zones (Brouwer *et al.*, 2010), components of the river basin (Poirier and Fleuret, 2010) or even on local, regional and national areas simultaneously (Baker *et al.*, 2007).

The geographic scale of the good involved in the CE context and the fact that the context in which a Choice Modeling (CM) survey is framed can influence preferences (Rolfe *et al.*, 2002) is well recognised. However, testing for geographic scale effects and scope differences has given mixed results. As Rolfe and Windle (2010) noted in a CM experiment, there are two key ways of varying the scope of the trade-off to be considered: (i) vary the geographic setting of the tradeoffs (*e.g.* at local, regional, national, or international levels), and (ii) through the choice and definition of attributes used in the choice sets. Changes in scale are generated through variation in the levels for each attribute.

As a result, the main differences in the estimation of WFD benefits are observed in the degree of benefits inclusion (valued as a bundle or separately) and the boundaries or size of the good. As a consequence of the latter, differences are also observed at the affected population. Other elements that vary include the nature of the good (rivers, lakes, coastal water) and the payment mode (council tax, water rates, general household payments). Hence, these differences as reflected in decision-making influence the relative results, which mean making comparisons is difficult.

In this thesis the approach of valuing the individual characteristics of river quality is adopted as it is regarded that although there exist indices of water quality that combine and merge different traits, the constituents of water quality as perceived by experts and the general public are likely to diverge. Therefore, although experts' classification of water quality is taken under consideration, public perception is also taken on board in order to see where the two intersect. The outcome of this cross-section is the employed river quality attributes of the study. In addition, as Pearce *et al.* (1994) note, the bio-chemical and bio-physical classifications that are currently used to measure environmental quality are prone to change because scientific procedures are constantly evolving and being updated.

One disadvantage of not using a one-dimension water quality index to represent river's health is that there is the possibility that some respondents might perceive the individual components of river's health as correlated (moving together). However, this issue can be accounted for in the modelling process accordingly, as will be explained in Chapter 4, when constructing the experimental design. On the other hand, the adopted approach gives the advantage of eliciting the value of the components of water quality that may be interesting from a policy perspective. This is relevant as policies in some cases are only interested in targeting specific water quality attributes that characterise and represent a particular site. That allowance makes this approach potentially more applicable in a BT framework where sites for example may share the same ecology demonstrated as poor river life (low abundance and diversity of fish and plants) but good aesthetics with respect to the appearance of the river's surface water. In addition, it explores the fact that individuals may prefer some river attributes to others. Furthermore, as observed in the studies that integrated all dimensions of water quality under one index, they do not necessarily adopt a common description as far as levels are concerned (Baker *et al.*, 2007 *versus* for example Brouwer *et al.*, 2010). As will be presented in Chapter 4, the research design of this study allows the comparison between a more 'holistic' approach to river quality valuation presented in a CVM context and the valuation of components of river quality in a CE framework.

2.2.4 BT for river quality improvements

A more cost-effective approach for the valuation of water quality improvements is expected to come through the application of BT. Although it is not the intention of this chapter to conduct an extensive literature review of BT studies, a brief overview is offered. An example is that of Johnson *et al.* (2008), who used BT in a stated preference study in England and Wales in order to calculate public WTP for a reduction in risk of illness resulting from swimming in contaminated river waters in Scotland. The study was framed in the context of EU Bathing Waters standards and the WFD.

Furthermore, the application of BT in the context of the WFD has been examined and tested in Hanley *et al.* (2006a, 2006b) by applying CE in two similar rivers and then exploring the possibility of using BT. Results from the two studies are different proving that BT is not a straightforward task to be applied in every case. In Hanley *et al.* (2006a), the authors attempted to explore the possibility of taking the estimates of WTP obtained from the River Wear and applying them to the River Clyde (or *vice-versa*) testing for the equality of parameters and WTP values. As the authors pointed out, a general way to find evidence of whether BT is advisable is to test the extent to which data from different samples can be pooled. In particular, considering the case of a multinomial model the equality of parameters across models was tested by using maximum likelihood extension of the Chow test for a structural break (Chow 1960) while the equality of WTP estimates across models was tested via the Wald test for non-linear restrictions (Wald 1939, 1943). The main findings of this study were that although the authors kept the survey instrument, the improvements to be considered and river's quality levels identical, both BT tests were rejected.

Hence, preferences and values differed significantly across the two samples. In particular, it seemed that people living near the River Clyde valued improvements more highly than those living near the River Wear although the first sample was of lower income compared to the second. As possible parameters that could explain the differences, the authors cite "the differences in the quality of nearby rivers (substitute sites), differences between the two rivers in terms of their natural characteristics (*e.g.*, hydrology, scale), differences in cultural attitudes to the two rivers and different uses to which the two rivers are currently put" (Hanley *et al.*, 2006a, p.192).

Hanley *et al.* (2006b) used the same policy concept of estimating the benefits of water quality improvements under the WFD to test the transferability of these improvements for two small catchments in Eastern Scotland of bad ecological status, the River Motray and the River Brothock. The authors estimated a random parameter model with independent and correlated preferences. In terms of BT tests it was found that implicit prices for river quality attributes were on the whole transferable across catchments following the standard Poe *et al.* (1994) test for differences in CS estimates and the alternative equivalence test (Kristofersson and Navrud, 2005). Finally, the authors suggested that policy makers should proceed with caution in transferring benefit estimates for water quality improvements under the WFD and should consider allowing for correlated preferences in their models since that may make a difference to the size and transferability of benefits.

Another application of BT in the context of water quality is that of Iovanna and Griffiths (2006). This study examined the use of BT methods to estimate ecological benefits as part of the total benefits assessment analysis for seven EPA rules issued under the Clean Water Act in the USA. Furthermore, Morrison and Bennett (2004) run seven CM applications designed to value improved river health in New South Wales so as to provide estimates to be used for BT in order to value improvements in the health of other rivers within the state. Significant differences were revealed between the majority of implicit prices for the within-catchment samples compared to out-of-catchment samples which did not reveal any difference.

Morrison *et al.* (2002) examined the validity of BT for two Australian wetlands in a CE context with mixed results. The estimated benefit functions of the two sites differed while the implicit prices equivalence showed insignificant differences for six of the eight implicit prices considered. On the other hand, CS equivalence was rejected in eight of the nine policy scenarios. Bergland *et al.* (1995) tested the transfer of WTP values for water quality improvement using two similar watercourses at the same point in time and with the same estimation methods. The significant differences found in benefit function drove them to the conclusion that any transfer of benefit values and/or functions between sites should be undertaken with extreme caution. Discussion of the BT method is further developed in Chapter 6 where an application of the method in the context of this thesis is also presented.

A study that combined BT but also some of the previously mentioned methods is that of Dubgaard (2004) and Dubgaard *et al.* (2005), who conducted a CBA of a river restoration project in Denmark (Skjern River project). As a result, the benefits' side included BT of CVM studies combined with pricing methods such as opportunity and purification cost methods. The analysis incorporated the existence value of increased biodiversity, the use value of improved possibilities for outdoor recreation, angling and hunting, as well as the purification effects of retaining ochre and nutrients, *etc*. The existence value of enhanced biodiversity was quantified through transfer of benefit estimates from a similar project area in the UK. Use values included improved opportunities for outdoor recreation, hunting and angling. The benefits of outdoor recreation were estimated by transferring WTP estimates from a valuation study of Mols Bjerge (a landscape of outstanding natural beauty in East Jutland). Visitation estimates were based on registered visit frequencies in similar areas. The value of improved angling opportunities was estimated through BT from a study of anglers' WTP in the Nordic countries. Benefits from improved hunting were calculated from data on the rental value of hunting rights in areas with habitat characteristics similar to the restored Skjern River valley. From the pricing methods perspective, the opportunity cost method priced benefits as the costs of obtaining the same effect through the best available alternative, whereas the purification cost method evaluated the benefits as the treatment costs associated with an alternative purification process. The cost side comprised the loss of land rent associated with a change in land use, along with project investments and costs of operation.

2.3 Literature review of river related studies in Ireland

In the case of Ireland, valuation studies with a focus on river quality improvements are limited. In particular, those available focus in valuing water-based leisure activities. Hynes and Hanley (2006) estimated through 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) a reduction (50%) in the recreational rating of a river due to water diversion for agricultural use was examined as was the unavailability of the river for kayaking due to the implementation of a hydro scheme. 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 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 which 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 original analysis. In late 2003, the Department of Environment, Heritage & Local Government commissioned research in relation to the evaluation of water supply and waste water schemes in Ireland (DKM *et al.*, 2004). Although no valuations on the external costs and benefits of these schemes were produced, the authors recommended that in the absence of specific Irish figures, UK values could be used under certain circumstances and conditions.

Indecon (2003) produced an economic evaluation of the salmon industry in Ireland. However, the findings were not based on WTP calculations but instead on actual revenues accruing to commercial salmon fishermen from fish sales and average expenditure incurred by salmon rod anglers in Ireland. Finally, it is worth mentioning that in Campbell's (2006) thesis on valuing rural environmental landscape improvements in Ireland, one of the landscape attributes used in the CE survey was Rivers and Lakes as they were highly regarded by the public for their contribution towards landscape aesthetic quality. This attribute was described in three levels (A lot of action, Some action, No action) with regard to implementing a nutrient management plan for all farms that would affect water appearance, fish and recreational uses. Results confirmed the importance of rivers and lakes for the public and indicated that this attribute was the one that attracted the most interest.

2.4 Chapter summary

This chapter reviewed the main stated preference valuation methods that are used as a tool by economists to capture different components of water resources value. Particularly, the weakness of revealed preference methods include benefits to individuals who are far away and who are not consumers of the good. This weakness gave rise to the stated preference methods which are presented in Section 2.2. Starting with CVM studies applied to value improvements in river quality related to different aspects like that of recreation, eutrophication, and flow conditions, the literature review refers to the latest CE studies from around the world in the field of valuation of river quality improvements. Studies are summarised in a table that reports the country of origin, the attributes and levels used.

Then emphasis was put on CE applications initiated by the EU WFD. This particular focus within the literature gives the opportunity to explore the different approaches of valuing the benefits resulting from full implementation of the WFD. It also serves as a template for choosing attributes and levels that have ultimately been considered in this thesis' application. Furthermore, applications of the BT method as a cost-effective alternative approach to benefits valuation are presented. Finally, the chapter also briefly presented the limited number of valuation studies in Ireland that are related to river quality improvements and hence pointed out the importance of this thesis contribution.

3

METHODOLOGY OF CHOICE EXPERIMENTS

3.1 Introduction

In this chapter the CE methodology is presented as a framework to the analysis of the data carried out in the following chapters. In this thesis, CEs formed the core of preferences' examination for river water quality improvements under the WFD. Therefore, an overview of the theoretical background, the relevant methodology and the estimation of CEs is offered.

In particular, the next section presents the theoretical background of discrete choice method and how the economic and econometric models are combined to explain individuals' preferences that follow a specific behavioural rule and are expressed by their stated 'choice'. The followed estimation process is then outlined along with guidance on goodness of fit and hypothesis testing. Furthermore, economic welfare measurement adds to a general description of the CM technique before the main discrete choice models employed by analysts are presented in Section 3.3. This overview starts from the MNL which is treated as a 'base' model (starting point), and then the Nested Multinomial (NMNL) and lately the Mixed Multinomial Logit model (MMNL) are explored. Finally, a brief overview of the chapter is offered in Section 3.4.

3.2 The choice modeling technique

3.2.1 Choice experiment background methodology

Primary originated in the market research and transport literature CM is relatively recently introduced in the field of the environment by Louviere and Timmermans (1990) and Adamowicz *et al.* (1994) who firstly applied CE to non-market valuation. Louviere and Hensher (1982) and Louviere and Woodworth (1983) developed the CE approach whose theoretical basis lies on Lancaster's microeconomic approach to consumer theory (Lancaster 1966). However, the origin of probabilistic CEs can be traced in Thurstone (1927) who developed the concept in terms of psychological stimulus, based on the 'Law of Comparative Judgment' that leads to a binary probit model of whether respondents can differentiate the levels of stimulus. Marschak (1960) 'translated' the stimuli into utility and provided a derivation from utility maximization signalling the start of Random Utility Maximisation models (RUM). The introduction of the Independence from Irrelevant Alternatives (IIA) axiom from Luce (1959), gave way to the derivation of the logit formula while Marschak (1960) proved that the IIA implies RUM.

Discrete models postulate that "the probability of individuals choosing a given option is a function of their socioeconomic characteristics and the relative attractiveness of the option" (Ortúzar and Willimsen, 2005, p.220). The 'attractiveness' is represented by the utility that the individual wants to maximize. Furthermore, utility is derived from the characteristics (Lancaster 1966) of the chosen option and those of the individual. In particular, according to Lancaster's approach individuals' utility is derived from good's different characteristics, as those are determined by varying levels, rather than the good *per se*. For example, the choice to buy a car may be dictated by attributes/characteristics such as its cost, comfort, engine performance. Likewise, a river's quality can be described for example in terms of its ecological status, recreational activities and appearance.

However, the fact that it is difficult to describe everything in terms of its attributes or that is possible to make errors in measuring attributes, gave place to the second strong link of CE with economic theory, that of random utility theory. The idea of utility maximisation that contains random elements was taken up by Marschak and further developed by McFadden (1974) linking the deterministic model to the statistical model. Under the assumption that an individual behaves in a utility-maximising manner and coupling that with random utility theory, observed consumer behaviour and economic theory were linked (Ben-Akiva and Lerman, 1985). Table 3.1 summarises the main steps that contributed to the development of CE.

Table 3.1: Literature related to CE development

Literature	*Date*	*Steps in CE development*
Thurstone	1927	Origin of probabilistic CEs
Luce	1959	Introduced the IIA axiom, derived logit formula
Marschak	1960	Introduced Thurstone's work into economics
Lancaster	1966	Consumer theory
McFadden	1973	Completed the analysis by showing the converse. Random utility theory

		Methodology
Louviere and Hensher	1982	CE technique was developed
Louviere and Woodworth	1983	CE technique was developed
		Application
Louviere and Timmermans	1990	First application in environmental economics
Adamowicz et al.	1994	First application in environmental economics regarding river improvements

CE is one of the stated preference techniques for valuing non-market goods that are grouped under the CM term. The other techniques are the contingent ranking, the contingent rating and paired comparisons. CE is one of the techniques that is definitely in line with the theory of welfare economics which allows estimating both use and non – use values. It should also be noted that CE is very similar to the CVM as far as the questionnaire design is concerned. However, differences are apparent in the valuation scenario section. In a CE framework respondents are asked from a given choice card to choose their most preferred alternative from a series of alternatives. They are usually asked to provide answers to a sequence of such choice cards. However, what distinguishes CE from CVM the most is the fact that the value of a good is derived by separately evaluating individuals' preferences for the most relevant attributes that characterize that good rather than eliciting the preferences for the good as a whole.

The following scheme (Figure 3.1) presents the main setting characteristics of a CE. It consists of a sequence of choice cards or tasks while each choice card contains a specific number of alternatives/profiles of a given 'good' (*e.g.,* river quality). Each alternative is determined by a number of attributes including the price. Each attribute is described by a level in each alternative situation.

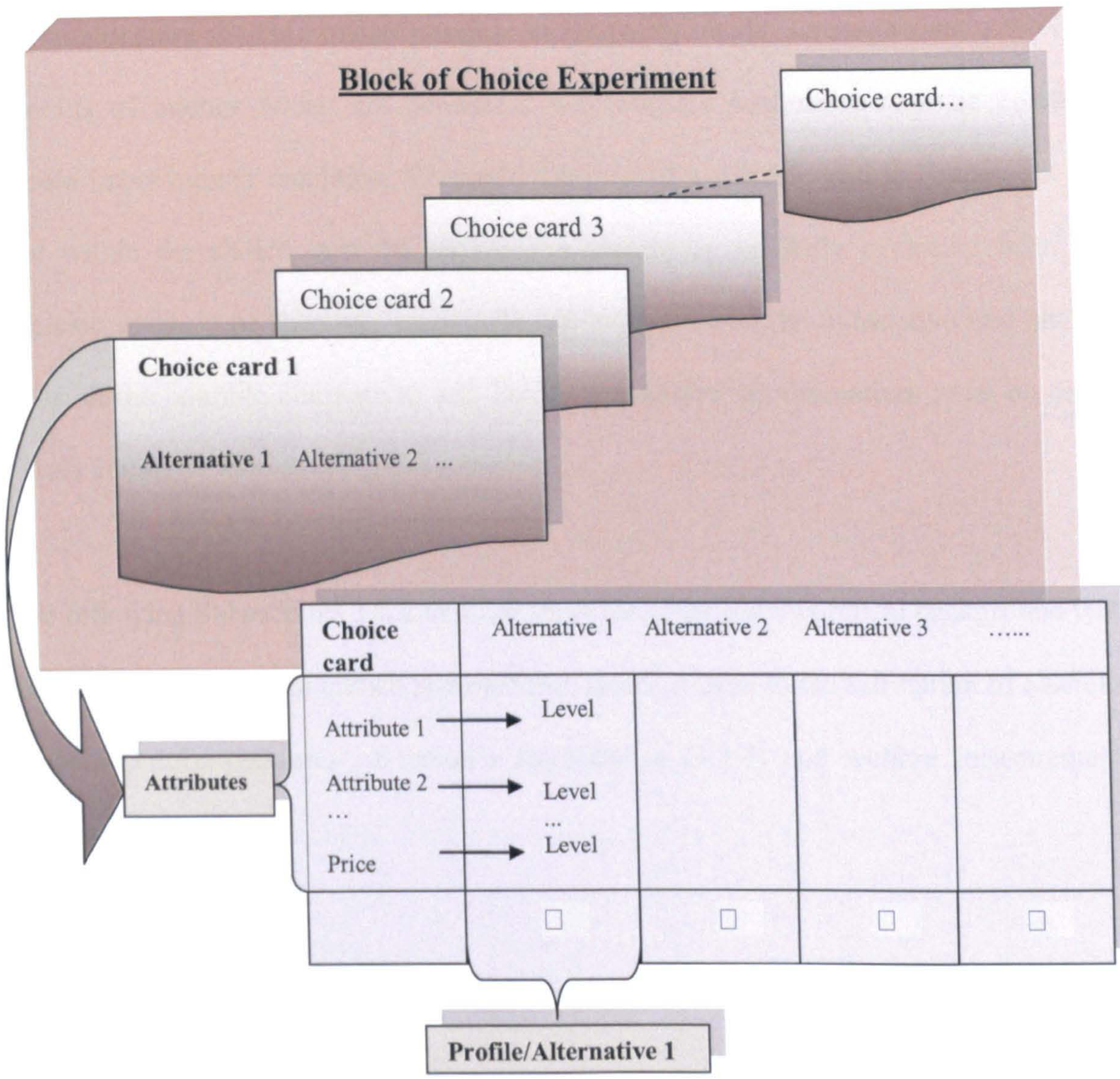

Figure 3.1: Choice Experiment (CE) setting

In this setting, according to Hanemann (1984), a 'discrete choice' is made on which 'alternative/good' to choose, as well as on how much ('continuous choice') to consume of the chosen 'alternative/good'.

The alternatives, presented in Figure 3.1, are constructed according to experimental design theory, which is commented on in Chapter 4, and which makes it possible to explore how an individual trades-off, by making a choice, some amount of an attribute, captured by its level, with another in the choice card. As it will be shown, the inclusion of the monetary attribute makes possible to indirectly obtain the respondent's WTP of benefits of interest which are consistent with welfare economics and the potential Pareto improvement condition. Common features of a discrete choice framework are that within the choice card the alternatives should be mutually exclusive from the decision maker's perspective, second the choice card must be exhaustive and should offer all the possible alternatives and finally the number of alternatives must be finite (Train 2009).

The following Subsections 3.2.2 to 3.2.6 show the steps and theoretical background that lead to the derivation of choice probabilities, issues related to the estimation of discrete models (3.2.5), measures of model's significance (3.2.5) and welfare measurement (3.2.6).

3.2.2 The economic model

Focusing on the economic model, the classical model of the utility maximising economic consumer that acts rationally provides the individual's behavioural rule. Hence, the starting point that is the basis for most microeconomic models of consumer behaviour is that each individual solves the utility maximization problem subject to a budget constraint.

Starting from the utility and following Alpízar *et al.* (2001), an individual's n preferences are described by the following conditional utility function which expresses the 'representatives' tastes of the population:

$$U_{ng} = V_{ng}(A_{ng}, p_{ng}, y_n) = V_{ng}(A_{ng}, y_n - p_{ng}c_{ng})$$

where A is the generic and alternative specific attributes of the alternative combination (profile) c_{ng}, p_{ng} is the price of the alternative g combination and y_n is the individual's n income. Then $y_n - p_{ng}c_{ng}$ represents the amount of goods that can be purchased. For simplicity the subscript n is omitted in most of the following sections.

The unconditional indirect utility function captures the discrete choice:

$$V[A, p, y] = max\,[V_1(A_1, y - p_1c_1) \ldots V_Z(A_Z, y - p_Zc_Z)] \tag{3.1}$$

Individual n, whose subscript is suppressed, chooses the alternative g if and only if:

$$V_g(A_g, y - p_g c_g) > V_h(A_h, y - p_h c_h),\ \forall\ h \neq g \tag{3.2}$$

Equations (3.1) and (3.2) complete the economic model for purely discrete choices and form the basis for the econometric model that stems from the acknowledgment that the researcher does not have full information about individual's true utility function U.

3.2.3 The econometric model

McFadden (1974) provided the general procedure for formulating econometric models of population choice behaviour from distributions of individual decision rules. In this framework, a model is defined as a set of individual behavioural rules since immeasurable individuals' characteristics vary across the population. McFadden defined the conditional probability (given a specific choice card and measured attributes) as an individual drawn at random from the population will choose alternative g, equal to the probability of occurrence of a decision rule yielding this choice. The econometric model uses the fact that the observed choice can be seen as a drawing from a multinomial distribution of selection probabilities which in their turn provide the estimators of the underlying parameters.

In order to make the economic model of Subsection 3.2.2 operational, the functional form of the utility function has to be determined and the unobservable behaviour, from the perspective of the analyst, captured. This unobserved behaviour which is derived by the fact that the analyst has incomplete information, brings uncertainty into the analysis that needs to be taken into account. In particular, the issues of unobservable characteristics of the individual or non-included attributes of the alternatives, measurement error and/or heterogeneity of preferences (Hanemann and Kanninen, 1999) are addressed through the random utility approach (McFadden, 1974). In this framework these effects are allowed and the deterministic model is linked to the statistical model of human behaviour.

More specifically, the conventional utility function includes a deterministic and observable part $(A, y - pc)$ and an error part (ε). The error part ε represents the idiosyncrasies of the individual in tastes for the chosen alternative/good, but also any measurement or observational errors made by the modeller. It should be noted here that ε is defined as the difference between the true utility U and the part of it that is observed by the researcher which is a function of $(A, y - pc)$. As a result, the researcher's specification of the deterministic part characterizes ε's. The utility is modelled as a random variable in order to reflect the involved uncertainty and it can be denoted as:

$$U = V(A, y - pc, \varepsilon)$$

In that framework the analysis becomes one of a probabilistic choice because of the error component whose value the analyst ignores and which is not possible to determine with certainty. As such, an individual will choose alternative g over alternative h of the same choice card S of M alternatives, if and only if:

$$P\{choose\ g\} = P\{V_g(A_g, y - p_g c_g, \varepsilon_g) > V_h(A_h, y - p_h c_h, \varepsilon_h);\ \forall\ h \neq g \in S\} \qquad (3.3)$$

Equation (3.3) indicates that the probability that a consumer will choose $g \in S$ equals the probability that the combined systematic and error components of g are higher than the systematic and associated error components for all other competing alternatives that belong to the same choice set S.

Hence, choice outcomes are observed up to a probability of occurrence as individuals' true utility is not observable since ε for each individual and for each alternative is not know. Therefore ε is treated as random. The joint density of the random variable ε is denoted $f(\varepsilon)$ and this density allows the researcher to make probabilistic statements about the individual's choice. How ε enters the conditional indirect utility function and the assumption about its distribution will determine the exact specification of the econometric model. The most common assumption is that the error term enters the utility function in additive form. In that case (3.3) is transformed to:

$$P\{choose\ g\} = P\{V_g(A_g, y - p_g c_g) + \varepsilon_g > V_h(A_h, y - p_h c_h) + \varepsilon_h\ \} =$$

$$P\{(V_g(A_g, y - p_g c_g) - V_h(A_h, y - p_h c_h)) > (\varepsilon_h - \varepsilon_g);\ \forall\ h \neq g \in S\} = \qquad (3.4)$$

The probability that each random term $\varepsilon_h - \varepsilon_g$ is below the observed quantity $V_g - V_h$ is a cumulative distribution. Hence, the probability of choosing g is a Cumulative Distribution Function (CDF) of sigmoid shape, presented in the following figure (Figure 3.2), that converges towards 1 as the difference in the estimated utility between the two alternatives increases and individuals are quite certain about their preferences. What matters are the differences in utility rather than their absolute levels.

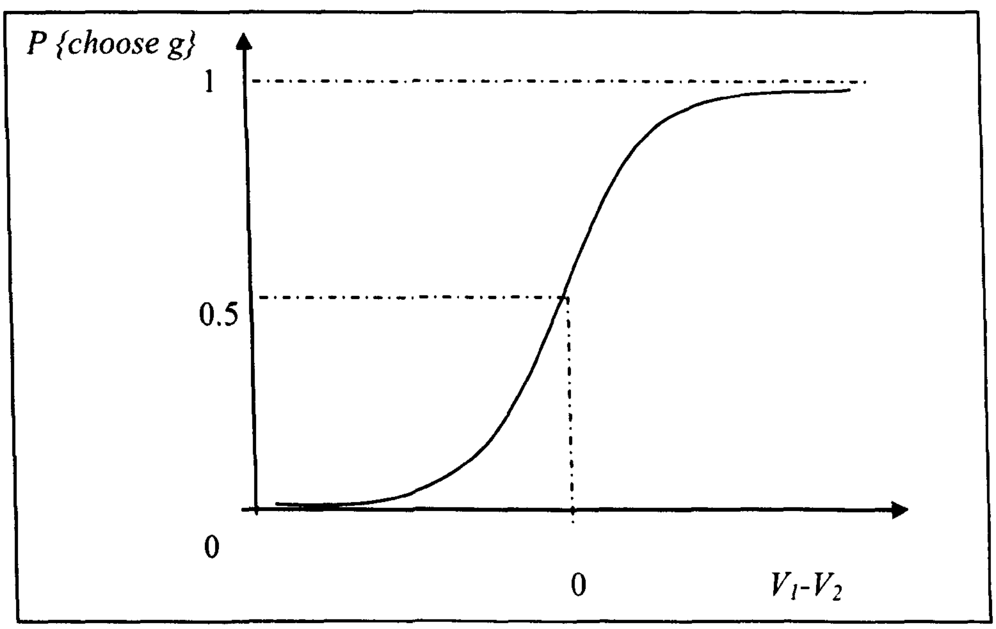

Figure 3.2: Cumulative Distribution Function (CDF)

Alternatively to (3.3), (3.4) demonstrates that option g will be chosen if the difference in the deterministic parts of alternative g compared to alternative h exceeds the difference in the error parts of utility of alternative h compared to g after evaluating each and every alternative in the choice set S. In other words, option g will be chosen if the error parts of utility of alternative h are less than the summation of the difference in deterministic parts of alternative g compared to alternative h plus the error parts of utility of chosen alternative g, as expressed in (3.5):

$$P\{\varepsilon_h < \varepsilon_g + (V_g(A_g, y - p_g c_g) - V_h(A_h, y - p_h c_h));\ \forall\ h \neq g \in S\} \qquad (3.5)$$

This choice probability in (3.5) is furthermore expressed in terms of the joint cumulative density function of the error term as:

$$P(choose\ g) = CDF_\varepsilon(\varepsilon_g + V_g(.) - V_1(.), \varepsilon_g + V_g(.) - V_2(.), \ldots, \varepsilon_g + V_g(.) - V_z(.)) \qquad (3.6)$$

The next step from here is to derive an explicit expression for this probability. Although, the distribution of the residuals ε is not known it is certain that the residuals are random variables with a certain distribution $f(\varepsilon) = f(\varepsilon_1 \ldots \varepsilon_Z)$. Following Train's (2009) interpretation of $f(\varepsilon)$, the density of $f(\varepsilon)$ is the distribution of the unobserved portion of utility within the population of people who face the same observed 'representative' utility as the individual. The distribution is due to the fact that among these people, that share the same observed utility, the values of the unobserved factors (error component) differ. Considering the existence of a distribution for the ε's the previous probability expression (3.5) can be written more concisely as:

$$P(choose\ g) = \int I[.] f(\varepsilon)\, d\varepsilon = \int_{\varepsilon_h = \varepsilon_g - V_g(.) - V_h(.)}^{\infty} f(\varepsilon)\, d\varepsilon = 1 - F(\varepsilon_g + V_g(.) - V_h(.)) \qquad (3.7)$$

Hence, stated in this form the probability of choosing option g is "an integral of an indicator $I\,[.]$ for the outcome of a behavioural process over all possible values of the unobserved factors". Alternatively, it can be expressed as "the expected value of the above indicator function, where the expectation is over all possible values of the unobserved factors" (Train 2009, p.4). The expression $I\ [\varepsilon_h < \varepsilon_g + V_g\ (.) - V_h\ (.)]$ can be used as an indicator that takes the value 1 when the statement in brackets is true and 0 when it is not. By integrating all the possible values of ε, the total probability of choosing alternative *g* is given.

Following Train (2009) there are three ways to evaluate the above integral and hence calculate the probability: complete closed form expression, complete simulation and partial simulation and partial closed form. The Sections 3.3.1 and 3.3.2 present the case of the integral's evaluation which concern models such as the multinomial logit, nested logit and mixed logit. Models like the logit and nested logit, that will be considered here, have closed form expressions for this integral which takes a closed form only for certain specifications of $f\ (.)$. When the integral does not have a closed form it is evaluated numerically through simulation like in the case of the mixed logit model.

What is needed is to assume a distribution for the error terms. Different models can be generated, as it will be explained in Section 3.3, depending on the distribution of ε. However, before citing the assumptions related to the models and the implications that they impose, there are two particular issues to keep in mind when it comes to the specification and estimation of any discrete choice model. The first, as showed before is that only differences in utility matter and the second is that the scale of utility is arbitrary.

In relation to the first, what is meant is that the alternative with the highest utility will be chosen even if a constant is added to the utility of all alternatives. To put it in Train's words "a rising tide raises all boats". From the analyst's perspective the choice probability is depended on differences in utility and not its absolute level. The main implication of this fact is that the only parameters that can be estimated are those that vary across alternatives. As such, alternative-specific constants (ASCs) that capture the average effect on utility of an alternative of all factors that are not included in the model, cannot be estimated for each alternative. A solution is to take one as a reference, fixing its value to zero, and interpret the estimated remaining as relative to the reference.

The same issue arises with socio-demographic characteristics of the respondent, such as gender or income, which do not vary over alternatives. Although these variables can enter the model in different ways it is common to interact them with attributes of the alternatives or with the Alternative Specific Constants (ASCs) (Hanley *et al.*, 2001). This point will be better explained when the choice probability will be derived in Section 3.3. A further implication of the issue that only differences in utilities matter is that the dimension of the integral that expresses the choice probability is reduced if we consider that with J errors (one for each alternative), there are $J - 1$ error differences. Since choice probabilities can always be expressed as depending only on error differences, one dimension of the density of $f(\varepsilon)$ is not identified and must be normalized by the researcher.

The second issue concerning the overall scale of utility has to do with the fact that the alternative with the highest utility will be chosen no matter how utility is scaled. Therefore it holds that the scale of utility is arbitrary. The normal way to standardise utility in order to take account of this fact is to normalize the variance of the error terms. The original coefficients are divided by the standard deviation of the unobserved portion of utility and the new ones reflect the effect of the observed variables relative to standard deviation of the unobserved factors. Normalisation can take place with Independently, Identically Distributed (IID) errors, with heteroskedastic errors and with correlated errors. Subsection 3.3.1.1 provides more information on scale parameter and its implications.

3.2.4 Estimation of discrete choice models

The Maximum Likelihood Estimation (MLE) is the most commonly used method for the estimation of the utility parameters of discrete choice models. MLE is described in Hensher *et al.* (2005) as an estimator that calculates parameters for which the observed sample is most likely to have occurred. Following Louviere *et al.* (2003) the idea behind this method is that a given sample could be generated by different populations and is more likely to come from one population than another. However, the ML estimates are the set of parameters which will generate the observed sample most often. MLE is used in complex problems like the simultaneous estimation of a number of parameters and in such difficult cases it is common to use the log of the likelihood function rather than the likelihood function in order to search for its maximum value. By taking the logarithm results in the summation of the log of values smaller than one, since probabilities are between 0 and 1, which produces negative Log-Likelihood (LL) values. The aim is to find the value of β that maximises the likelihood or minimizes the absolute value of the LL. The optimal solution for the LL function, as presented in the following figure (Figure 3.3), will be the point that is closest to 0 (Hensher *et al.*, 2005).

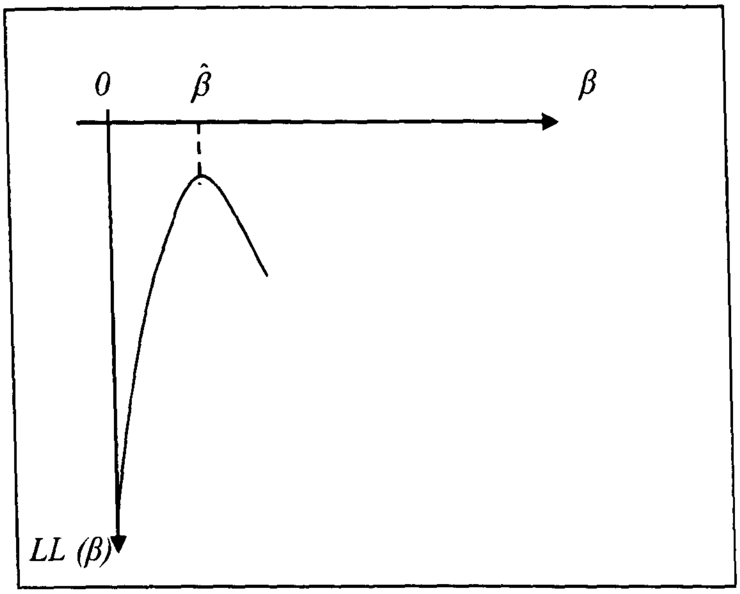

Figure 3.3: Maximum Likelihood Estimation (MLE)

The likelihood function can be expressed as the product of the model probabilities that each individual chooses the option s/he actually selected:

$$L(\beta) = \prod_{n} \prod_{g} (P_{ng})^{y_{ng}} \quad (3.8)$$

where $y_{ng} = 1$ if person n chose g and 0 otherwise. The LL function is then:

$$LL(\beta) = \sum_{n} \sum_{g} y_{ng} \ln(P_{ng}) \quad (3.9)$$

3.2.5 Overall model significance and hypothesis testing

In order to determine if the overall model is statistically significant, the LL function of the choice model at convergence is compared to the LL function of some other 'base model' (Hensher *et al.*, 2005). Following Louviere *et al.* (2003) the LL function evaluated at the mean of the estimated utility parameters is a useful criterion for assessing overall goodness-of-fit when the ML method is used to estimate the utility parameters of discrete choice models. The McFadden's (1974) likelihood ratio index is employed, as a type of pseudo-R^2, in order to measure how well the model with its estimated parameters performs (fit the data) compared with a model in which all the parameters are zero (that is having no model at all) (Train 2009). The contribution of LL makes this comparison possible as it is evaluated at both the estimated parameters and at zero for all parameters. In particular, this index is defined as:

$$pseudo-R^2 = \rho = 1 - \frac{LL(\hat{\beta})}{LL(0)} \quad (3.10)$$

where $LL(\hat{\beta})$ is the log-likelihood function at the estimated parameters and $LL\ (0)$ is its value when all the parameters are set equal to zero. The pseudo – R^2 statistic can be seen as the percentage increase in the LL function above its value when all the parameters are zero. If the estimated model is no better than no model then $LL\ (\hat{\beta}) = LL\ (0)$ and $\rho=0$. On the other hand, if the model predicts perfectly decision-makers choice then $LL\ (\hat{\beta}) = 0$ (since the log of choice probability one is zero) and $\rho=1$. As a result, the likelihood ratio index ranges from 0 (its lowest value, no fit) to 1 (its maximum value, perfect fit). However, as Train (2009) noted although this index is useful and meaningful comparing two models estimated on the same data and with the same set of alternatives (the model with the higher ρ fits data better), it is not the same for two models estimated on samples that are not identical or with different set of alternatives, since $LL\ (0)$ is not the same for both models.

On the other hand, as noted in Hensher *et al.* (2005) the R^2 statistic associated with choice models is not exactly analogous to the R^2 statistic associated with linear regression model, simply because in the former the underlying choice analysis is not linear. However, Domencich and McFadden (1975) showed that there exists a direct empirical relationship between the two R^2's. Considering the mapping of this relationship Hensher *et al.* (2005) argued that in their experience pseudo – R^2 values between the range of 0.3 and 0.4 can be translated as an R^2 of between 0.6 and 0.8 for the linear model equivalent which represents a decent model fit for a discrete choice model.

Other measures that count for loss of degrees of freedom from model's expansion are the Akaike information criterion (AIC) and the Bayesian information criterion (BIC) that can be considered as adjusted goodness of fit measures (Greene 2003) and which are calculated as follows:

$$AIC = -2(LL(\hat{\beta}) - P) \quad (3.11)$$

$$BIC = -LL(\hat{\beta}) + (P/2) \times ln(N) \quad (3.12)$$

where P is the number of estimated parameters and N is the number of respondents in the sample. Considering these two measures, the smaller the statistics the better the model.

As far as hypothesis testing of individual parameters in discrete choice models are concerned, standard t-statistics are employed. If the hypotheses to be tested are more complex of the following type: (i) several parameters are zero and (ii) two or more parameters are equal, a Likelihood Ratio (LR) test can be used where the ratio of likelihoods is: $R = \frac{L(\hat{\beta}^H)}{L(\hat{\beta})}$ and the test statistic is $-2(LL(\hat{\beta}^H) - LL(\hat{\beta}))$ where $\hat{\beta}^H$ is the constrained maximum value of the likelihood function (not logged) under the null hypothesis H, and $\hat{\beta}$ is the unconstrained maximum of the likelihood function. If the value of the test statistic exceeds the critical value of chi-squared with the appropriate degrees of freedom (equal to the number of restrictions implied by the H), then the null hypothesis is rejected and that implies that the restricted model is erroneous. Assuming that the sample size remains constant and that the same choice variable is used two different choice specifications can be compared using the LR-test (Hensher *et al.*, 2005).

3.2.6 Welfare measurement

The estimation of the parameters offers the possibility to the analyst to proceed to the derivation of WTP welfare measures for a policy change that impacts on the environmental good under question. In particular, in the case of a CE application, the researcher's interest is on the estimation of welfare effects of changes in the attributes of the good.

Assuming a constant marginal utility of income and adopting the following conditional utility function with independence of personal characteristics, it is shown that income does not affect the probability of choosing a certain alternative and the welfare measures have no income effect (Alpízar *et al.*, 2001). Hence, the starting point is the conditional utility function:

$$V_g(A_g, p_g, y, \varepsilon) = h_g(A_g) + \bar{\gamma}(y - p_g c_g) + \varepsilon \qquad (3.13)$$

where $\bar{\gamma}$ represents the marginal utility of money (or reverse marginal disutility of cost), $h(A)$ captures the effect of the different attributes on utility and A represents the attributes that describe the good, p is the price and y is the income as denoted previously.

Furthermore, the probability that alternative g is chosen over alternative h of the same choice set S of M alternatives is given by (3.14):

$$P\{choose\ g\} = P\{h_g(A_g) + \bar{\gamma}(y - p_g c_g) + \varepsilon_g > h_h(A_h) + \bar{\gamma}(y - p_h c_h) + \varepsilon_h; \forall g \neq h \in S\} \quad (3.14)$$

Following that the welfare measures will have no income effects, the unconditional indirect utility function is:

$$v(A, p, y, s) = \bar{\gamma} y + \max[h_1(A_1) - p_1 c_1 + \varepsilon_1, ..., h_Z(A_Z) - p_Z c_Z + \varepsilon_Z] \quad (3.15)$$

In order to explore the economic welfare impact of an environmental quality change in an attribute it requires to compare situations before and after the change as expressed in the following equality: $V(A^0, p^0, y) = V(A^1, p^1, y - CV)$, where V *[..]* captures the discrete choice, CV is the Compensating Variation, $V(A^0, p^0, y)$ denotes the representative component of utility before the change and $V(A^1, p^1, y - CV)$ denotes the representative component of utility after a change in attribute(s) from A^0 to A^1. From the above equality it is possible to derive the economic welfare impact of the change from A^0 to A^1, which is the *CS* since alternative quantities are fixed as with an environmental public good. Using the functional form of the unconditional indirect utility function above, the equality $V(A^0, p^0, y) = V(A^1, p^1, y - CV)$ is expressed as:

$$\begin{aligned} &\bar{\gamma} y + \max[h_1(A_1{}^0) - p_1{}^0 c_1 + \varepsilon_1, ..., h_Z(A_Z{}^0) - p_Z{}^0 c_Z + \varepsilon_Z] = \\ &\bar{\gamma}(y - CV) + \max[h_1(A_1{}^1) - p_1{}^1 c_1 + \varepsilon_1, ..., h_Z(A_Z{}^1) - p_Z{}^1 c_Z + \varepsilon_Z] \end{aligned} \quad (3.16)$$

Solving (3.16) for CV results in (3.17):

$$CV = \frac{1}{\bar{\gamma}}\{\max[h_1(A_1{}^1) - p_1{}^1 c_1 + \varepsilon_1, ..., h_Z(A_Z{}^1) - p_Z{}^1 c_Z + \varepsilon_Z] - \max[h_1(A_1{}^0) - p_1{}^0 c_1 + \varepsilon_1, ..., h_Z(A_Z{}^0) - p_Z{}^0 c_Z + \varepsilon_Z]\} \quad (3.17)$$

In a multiple alternatives context where quality change involves many alternatives, if the errors are extreme value distributed the expected CV for a change in attributes is (Hanemann, 1999):

$$E(CV) = \frac{1}{\mu\bar{\gamma}}\left\{\ln \sum_{g \in S} \exp(\mu V_g{}^1) - \ln \sum_{g \in S} \exp(\mu V_g{}^0)\right\} \quad (3.18)$$

where $\mu \bar{\gamma}$ is the confounded estimate of the scale parameter and the marginal utility of money respectively and S is the choice set. The change in compensating surplus that results from a change in alternatives and/or choice set is calculated from (3.18). In the case of a linear utility function and only one attribute changing the CV is the ratio of the attribute coefficient and the marginal utility of income:

$$CV = \frac{1}{\gamma}\ln\left\{\frac{\exp(V_g^{\,1})}{\exp(V_g^{\,0})}\right\} = \frac{1}{\gamma}(V^1 - V^0) = \frac{\beta_m}{\gamma}(A_m^{\,1} - A_m^{\,0}) \tag{3.19}$$

Thus the marginal WTP for a change in an attribute, known as implicit price, is:

$$MWTP_m = -\frac{\beta_m}{\gamma} \tag{3.20}$$

Something that should be remembered here is that when the ratio is considered the scale disappears.

Specifying t-ratios or standard errors for these ratios can be complex since each WTP estimate is the ratio of two parameters each of which is an estimate surrounded by a range of uncertainty (Bateman *et al.*, 2002). Hence, even if the two parameters are statistically significant that does not mean that the ratios are significant too. The authors in Bateman *et al.* (2002) propose the following expression as one approximate solution for the variance of the ratio of two estimates. In particular:

$$Var\left(\frac{\beta_g}{\beta_h}\right) = \left(\frac{\beta_g}{\beta_h}\right)^2 \left(\frac{\mathrm{var}(\beta_g)}{\beta_g^{\,2}} + \frac{\mathrm{var}(\beta_h)}{\beta_h^{\,2}} - \frac{2\,\mathrm{cov}(\beta_g, \beta_h)}{\beta_g \beta_h}\right) \tag{3.21}$$

Alternative approaches to calculate standard errors of the welfare measures are bootstrapping (which resides in simulation in order to establish the empirical distribution of WTP) and the Krinsky-Robb procedure that estimates the empirical distribution based on *N* random drawings from the multivariate normal distribution defined by the coefficients and covariance matrix estimated from the logit model

(Krinsky and Robb, 1986). The welfare is then calculated for each one of these draws. In particular, given the bootstrap parameter vector, mean WTP is computed and stored. Computing and storing bootstrap replications of mean WTP yields a bootstrap distribution of the median for each equation. Sorting the mean WTP bootstrap distribution allows confidence intervals to be established, and hypothesis tests can be constructed. This technique is used more often than the traditional bootstrap technique in estimating WTP confidence intervals because of its relative efficiency. As noted in Alpízar *et al.* (2001), although this approach is less computationally burdensome than bootstrapping, its success critically depends on how closely the distribution of errors and the asymptotically normal distribution coincide.

3.3 Overview of discrete choice models

3.3.1 Multinomial logit model

To derive the MNL a specific distribution for unobserved utility is required. This model is considered as the simplest and most popular practical model known as the 'workhorse' of discrete choice analysis (Hensher *et al.*, 2005) and is derived by assuming that each ε (for each individual and alternative) is IID extreme value. As Hensher *et al.* (2005) noted, the difference between this distribution and the normal is in the tails where the extreme values reside. However, the key assumption of the model is not so much the shape of the distribution as that the errors are independent from each other. In simple words, that means that the unobserved portion of utility for one alternative: (i) is unrelated to the unobserved portion of utility for another alternative, (ii) is has its own unique mean value (to reveal different ASCs) and (iii) has the exact same distribution with another unobserved component. Utility functions with IID residuals generate an important class of random utility models with the main property that alternatives should be independent and not correlated. The typical assumption that errors are IID with an extreme value type I (Gumbel) distribution, leads to the following distribution functions:

Density for each unobserved component of utility:

$$f(\varepsilon) = \exp(-\varepsilon)\exp(-\exp(-\varepsilon)) \tag{3.22}$$

CDF is:

$$F(\varepsilon) = \exp(-\exp(-\varepsilon)) \tag{3.23}$$

Summarising the implications of the assumption of the independent extreme value (Gumbel) ε's in the MNL model framework, it is noted that the random part of each utility is derived by (3.23), there is independence across utility functions, there are identical variances (the means are absorbed in constants) and the parameters are the same for all individuals. This distribution of the error terms implies that the probability of any particular alternative g being chosen can be expressed in terms of the logistic distribution (McFadden 1974) since the difference between two extreme value variables is distributed logistic: $F(\varepsilon_g - \varepsilon_h) = \frac{\exp(\varepsilon_g - \varepsilon_h)}{1+\exp(\varepsilon_g - \varepsilon_h)}$. Now following McFadden (1974) the probability that our decision-maker choosing alternative g is as previously derived in (3.5):

$$P\{\varepsilon_h < \varepsilon_g + (V_g(A_g, y - p_g c_g) - V_h(A_h, y - p_h c_h)); \ \forall \ h \neq g \in S\}$$

If ε_g is given, this expression is the cumulative distribution for each ε_h evaluated at ε_g + $(V_g(A_g, y - p_g c_g) - V_h(A_h, y - p_h c_h))$, which according to (3.23) CDF is $exp(-exp(-(\varepsilon_g + V_g(.) - V_h(.))))$. Since ε's are independent, this cumulative distribution over all $h \neq g$ is the product of the individual cumulative distributions:

$$P\{choose \ g \mid \varepsilon_g\} = \prod_{h \neq g} \exp(-\exp(-(\varepsilon_g + V_g(.) - V_h(.)))) \qquad (3.24)$$

Since ε_g is not given the choice probability is the integral of $P\{choose \ g \mid \varepsilon_g\}$ over all values of ε_g weighted by its density (3.22):

$$P\{choose \ g \mid \varepsilon_g\} = \int \left(\prod_{h \neq g} \exp(-\exp(-(\varepsilon_g + V_g(.) - V_h(.)))) \right) \exp(-\varepsilon_g) \exp(-\exp(-\varepsilon_g)) d\varepsilon_g \qquad (3.25)$$

After algebraic manipulations of this integral the logit closed expression of the logit choice probability is derived which leads to the conditional logit model or MNL:

$$P\{choose \ g\} = \frac{\exp(\mu V_{ng})}{\sum_{h \in S} \exp(\mu V_{nh})}; \ \forall \ g \neq h \in S \qquad (3.26)$$

The probability of an individual n choosing alternative g out of the set of available alternatives in the choice set S is equal to the ratio of the exponential of the observed utility index for alternative g to the sum of the exponentials of the observed utility indices for all alternatives, including the g^{th} alternative (Hensher *et al.*, 2005). Since representative utility is usually specified to be linear in parameters: $V_{ng} = \beta' x_{ng}$, where x_{ng} is a vector of observed variables relating to alternative g, with this specification the logit probabilities become:

$$P\{choose\ \mathrm{g}\} = \frac{\exp((\mu\beta')x_{ng})}{\sum_{h \in S} \exp((\mu\beta')x_{nh})} \tag{3.27}$$

Furthermore, if included are the individual's characteristics w_n with parameters α' to be estimated then the above choice probability is expressed as:

$$P\{choose\ \mathrm{g}\} = \frac{\exp(\mu(\beta' x_g + \alpha' w_n))}{\sum_{h \in S} \exp(\mu(\beta' x_h + \alpha' w_n))} = \frac{[\exp(\mu\beta' x_{ng})]\exp(\mu\alpha' w_n)}{\left[\sum_{h \in S} \exp(\mu\beta' x_{nh})\right]\exp(\mu\alpha' w_n)} \tag{3.28}$$

From this expression it is clear that terms that do not vary across alternatives like those specific to the individual (w_n) fall out of the probability and the model needs to be modified in order to allow for individual specific effects. The choice probability can be expressed in an even more succinct form by dividing the numerator and denominator of the above choice probability by its numerator. In that case, the choice probability takes the following form:

$$P\{choose\ \mathrm{g}\} = \frac{1}{1 + \sum_{h \in S} \exp\left((\mu\beta')x_{nh} - (\mu\beta')x_{ng}\right)} \tag{3.29}$$

The relation of the logit probability to representative utility is sigmoid, or *S*-shaped, as shown in Figure 3.4. This shape shows that the impact of changes in the explanatory variables of the representative utility have greatest effect on the probability of the alternative *g* to be chosen when the probability is close to 0.5.

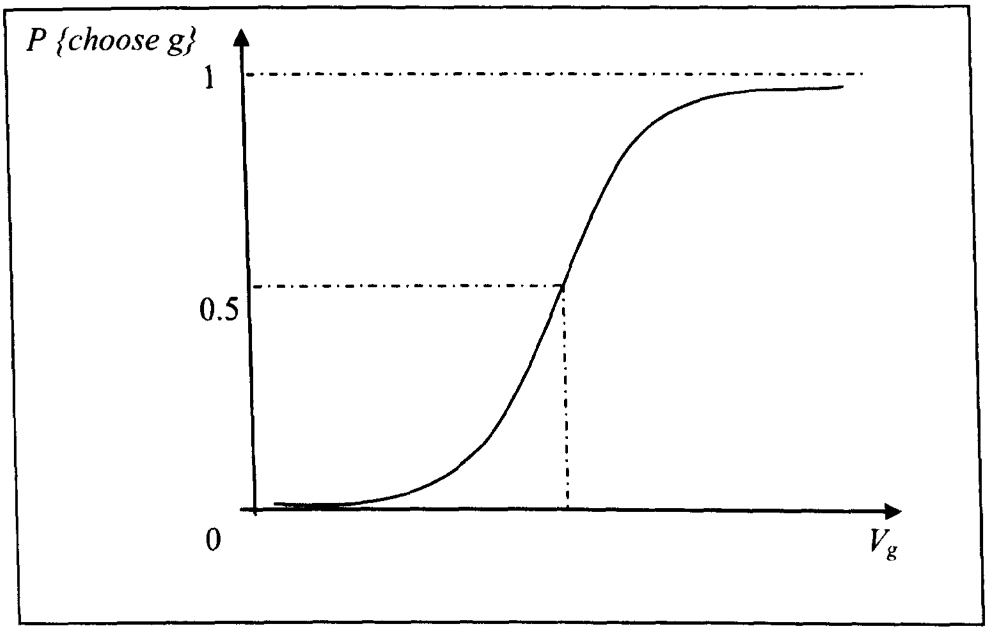

Figure 3.4: Graph of logit curve

3.3.1.1 The scale parameter

One parameter that characterises the distribution of the unobserved factors, apart from the fact that are distributed extreme value, is the scale parameter μ that takes its name from the fact that it scales the coefficients to reflect the variance of the unobserved portion of utility. The implication is that μ and β' are not separately identified and when the parameters β's are estimated it is useful for interpretation to recognise that these estimated parameters correspond to the 'original' coefficients that are multiplied by the scale parameter μ. As referred in Train (2009) the estimated coefficients indicate the effect of each observed variable relative to the variance of the unobserved factors. That is because the scale parameter is inversely proportional to the variance of the distribution such that $Var_{\varepsilon n} = \frac{\pi^2}{6\mu^2}$ where $\pi^2 = 3.14159^2$ and μ is the unknown scale parameter. This squared scale parameter is what describes the profile of the variance of the unobserved effects associated with an alternative. The fact that the variance is an inverse function of the scale shows that an increase in scale reduces the variance and leads to smaller coefficients even if the 'original'/observed factors have the same effect on utility. As Alpízar *et al.* (2001) noted, that means that high fit models have larger scales. The influence of the scale factor of a data set that implies the inverse relationship between the scale factor and the variance of the error terms is presented in Figure 3.5. As shown in the figure: (1) when scale is zero the choice probabilities are equal (in the binary case shown in the figure, both probabilities equal one half), (2) as scale grows from there, the choice model predicts more and more like a step function, which is to say, it becomes perfectly discriminating between the two alternatives in the graph. This effect generalizes for more than two alternatives.

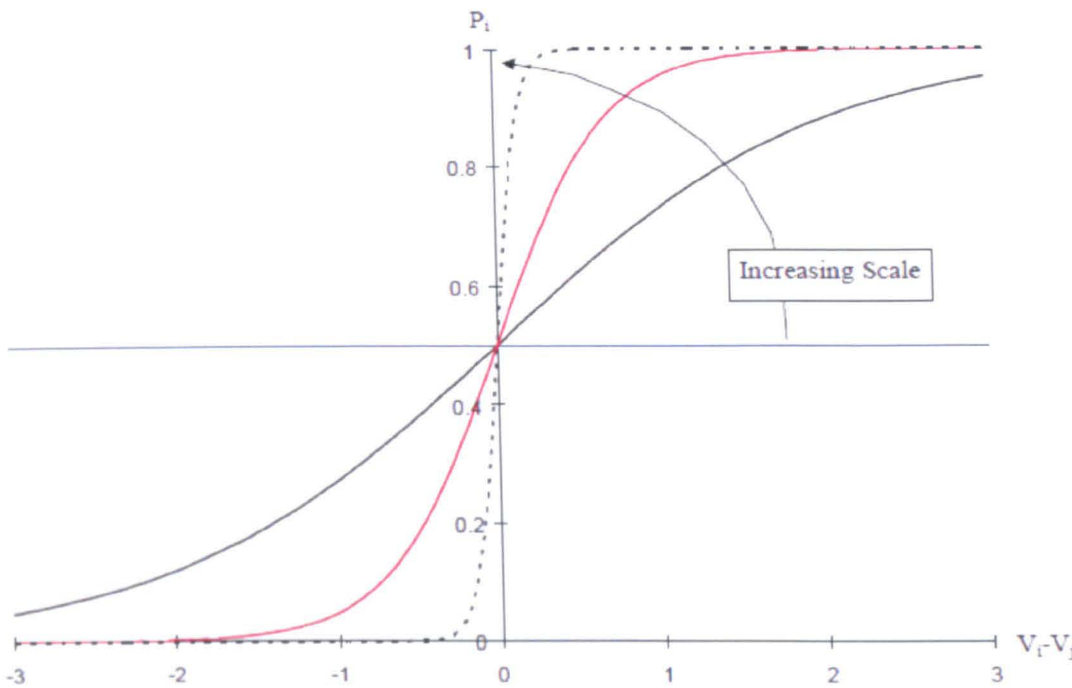

Figure 3.5: The effect of scale parameter on choice probability (Source: Adamowicz *et al.*, 1998)

On the other hand, the scale parameter does not affect the ratio of two coefficients, like this of WTP, since it drops out of the ratio. In that case what is affected is the interpretation of the magnitude of all coefficients. However, Louviere (2006) noted that the fact that WTP specification cancels scale makes empirical sense only if errors are IID.

As noted in Bateman *et al.* "the value of μ is irrelevant to calculate relative welfare estimates if the utility function is linear in income, since it weights everything the same" (2002, p.280). However, it is necessary to consider that "different random component variances can lead to different predicted distributions of welfare estimates, even if one constrains the systematic component parameters to be equal for subsamples" (Louviere *et al.*, 2002, p.180). Hence, one more implication of the presence of this parameter is that it influences the total absolute measures of value and therefore it is not safe to compare two CE models from different data sets assuming that the scale parameter is the same in both even if the two populations have identical parameters (Morrison *et al.*, 1999a). The idea is that data from different data sets can often be expected to have different variance for unobserved factors and hence a different scale parameter. On the contrary the scale remains the same within an estimated model and is valid to compare signs and relative sizes. Swait and Louviere (1993) provided the procedure of how to estimate and use the ratio of scale parameters in order to adjust for differences in error variance and hence compare estimated parameters from two different data sets or combine data sets.

Louviere *et al.* (2008) emphasized that the assumption of homoskedastic error variances, across all decision-makers since μ is the same for all individuals, leads to large biases and what it is observed is 'scale' heterogeneity rather than 'taste' heterogeneity. If that issue is not properly accounted for it can have serious policy implications.

Louviere and Eagle (2006) noted that it is more likely that error variances systematically vary in empirical data with attribute levels varied in CEs and real markets and differences in individuals. A consequence of this is that it impacts magnitudes of estimated model parameters and by implication statistical inference. The authors acknowledge the fact that all models confound scale and parameter estimates. They also pointed out that one cannot estimate individual-level parameters from choice models unless one can separate scale and model parameter estimates. They offered two potential ways to do this; covariance heterogeneity models and estimating models for single persons.

Accordingly, following Louviere's *et al.* (2002) attempt to decompose and understand Var_{ε} in a behavioural sense, the variability in response outcomes and random components can be associated with many factors and should not simply be lumped either into a single 'error term' (because of the μ=1 assumption) or attributed entirely to heterogeneity. Hence, the focus of research should be more on the variability of the random component of response outcomes rather on the variability in mean response outcome. In particular, as far as the factors associated with random components are concerned the authors argue that these factors are the same as those that affect outcome (*Y*=vector of behavioural outcomes) which is described by the following equation/conceptual framework (Louviere 2006):

$$Y| X; Z; C; G; T;$$

where *X* is a matrix of directly observable or manipulated variables such as prices, advertisements, product features/attributes; *Z* is a matrix of observed individual characteristics such as age, income, or psychographics; *C* is a matrix of factors that vary over conditions, contexts, circumstances or situations such as different trip purposes, types of purchase occasions, or complete/incomplete information conditions in experiments; *G* is the matrix of geographical/spatial or environmental characteristics that may vary from place to place such as travel times, climate, distribution channels, channel coverage, *etc.* and finally matrix *T* of time – varying factors. In addition to the above variables there is an irreducible response variability (or error) inherent to human behaviour that cannot fully be understood and captured.

Quoting Louviere *et al.* (2008) "differences in scale and how to anticipate is the next innovation in the field ... behavioural theory is missing not statistics that run ahead...we need a new theory about $Var_{\varepsilon n}$...we need models to differentiate scale and preference heterogeneity so confoundment is not a issue". Again Louviere and Eagle (2006) emphasised that more research is needed to separate parameters and scale and multiple sources of data need to be combined in order to make real progress in separating components of variance.

In this direction Flynn *et al.* (2007) presented the approach of 'best-worst' scaling as an alternative to the traditional discrete choice experiment. Subjects report most and least preferred options and/or report additional most and least preferred options from the remaining options, until some/all options are ranked (Louviere 2006). The authors argued that this method offers richer insights and additional information that could be employed to make individual-level inferences and model individual-level utility functions rather than trying to introduce more complex random effects models in order to accommodate respondent heterogeneity that may not be due necessarily to preference heterogeneity. It should be noted that 'attribute level scale' should not be confused with 'variance scale factors' (μ). The first scale issue is related to the importance or impact of an attribute on an individual's choice and is the focus point of Lancsar *et al.* (2007) who included 'best-worst' attribute scaling as one of the five methods that allow comparisons of the relative attribute impact of each employed attribute. Other methods that overcome the confoundement of the underlying subjective scale of utilities are the partial LL analysis, the marginal rate of substitution for non-linear models, the Hicksian welfare measures and the probability analysis.

Although it is very difficult to explore all sources of variability this thesis' research design offers some potential to examine variance variability within and across datasets. The use of separate experimental designs and samples posed the question of whether or not the scale parameter would be different for the discrete choice specifications fitted to the pooled sample responses since different designs imply different degrees of task complexity in the choice tasks faced by respondents. Furthermore, different degrees of task complexity exist not only between the two different samples for which a different design was used but also within each sample where for example, different sets of choice cards were employed. As a result, special emphasis is put on the issue of scale in the analysis that follows.

Furthermore, the within individual behavioural variation is explored through the inclusion of a set of psychometric questions. Follow-up questions attempt to gauge and map different rules of behaviour when it comes to decision-making, including discontinuous preferences too. These issues are presented in more detail in Chapter 4 where the questionnaire is described and Chapter 8 which analyse the responses from the related follow-up questions.

3.3.1.2 A note on MNL

Although it relies on restrictive assumptions, the simplicity of estimation of the MNL model makes it popular. However, it is important for the researcher to be aware of its power and limitations. In particular, following Train (2009) there are three topics that summarize its applicability.

The first deals with taste variation and the fact that although logit can represent taste variation that relates to observed characteristics of the decision maker it cannot represent random taste variation that is differences in tastes that cannot be linked to observed characteristics. As a result, if taste variation is at least partly random, then the conditional logit is a misspecification. In order to incorporate random taste variation appropriately and fully, a probit or mixed logit model can be used instead.

The second issue is that the logit model implies a certain type of substitution across alternatives - the proportional substitution; and in order to capture more flexible forms of substitution other models are needed. The issue of a certain pattern of substitution arises from the independence of the Gumbel error terms across the different options contained in the choice set that gives place to the property of the IIA which is an important behavioural assumption of the standard logit model. 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. As noted in Hensher *et al.* (2005, p.479) an important behavioural implication of this property is that all pairs of alternatives are equally similar or dissimilar. Furthermore, for the unobserved factors this assumes that "all the information in the random components is identical in quantity and relationship between pairs of alternatives and hence across all alternatives (hence the IID condition)". However, although this property facilitates estimation and may be an accurate reflection of reality in some choice situations that can be approached as binomial, it is implausible for alternative sets containing choices that are close substitutes (McFadden, 1974). For example consider the famous red bus- blue bus problem. In such cases the MNL is not the appropriate model to use. Hausman and McFadden (1984) proposed a specification test, contacted in two stages, for the MNL model to test the IIA assumption. In particular, at the first stage the *full* model with 'irrelevant alternatives' is estimated and then a 'short' model is estimated eliminating the irrelevant alternatives. The 'short' model is derived by eliminating individuals who chose the irrelevant alternatives and by dropping attributes that are constant in the surviving choice set. Hence, the second model is characterised by a restricted set of alternatives but the same attributes. Next thing is to observe if the coefficients change. The test statistic is:

$$H = \left(\mathbf{b}_{short} - \mathbf{b}_{full}\right)'\left[\mathbf{V}_{short} - \mathbf{V}_{full}\right]^{-1}\left(\mathbf{b}_{short} - \mathbf{b}_{full}\right) \tag{3.30}$$

where $\boldsymbol{b}$ is a column vector of parameter estimates and $\boldsymbol{V}$ is the variance-covariance matrix. The statistic has a limiting chi-squared distribution with degrees of freedom equal to the number of parameters estimated. If the Hausman statistic is large, then the IID is rejected and the data are no consistent with that assumption. So, in case that property IIA is violated and the ratio of probabilities for two alternatives changes with the introduction or change of another alternative, as previously mentioned other less restrictive choice models like nested logit, probit and mixed logit can be employed.

More specifically, if the unobserved factors distribution implies that the unobserved portion of utility for one alternative is related to the unobserved portion of utility for another alternative and hence IID is violated, then the researcher is left with three choices (Train 2009): (a) use a different model that allows for correlated errors, for example a mixed logit model, (b) re-specify representative utility so that the source of the correlation is captured explicitly and thus the remaining errors are independent, or (3) use the logit model under the current specification of representative utility, considering the model to be an approximation if that is consistent with the goals of the research.

The third issue is related to the panel data that are generated when the researcher asks respondents a series of hypothetical choice situations. In such a setting, the conditional logit can capture the dynamics of repeated choice but only if unobserved factors are independent over time in repeated choice situations. Although dynamics related to observed factors can be accommodated, it is not the same for dynamics associated with unobserved factors, since the unobserved factors are assumed to be unrelated over choices. If that is not the case, the researcher, as stated before, and according to Train (2009, p.52) "can either use a model such as probit or mixed logit that allows unobserved factors to be correlated over time, or re-specify representative utility to bring the sources of the unobserved dynamics into the model explicitly such that the remaining errors are independent over time".

To summarise, Alpízar *et al.* (2001) pointed out that the two main problems that arise with the MNL specification are that (i) the alternatives are independent and that (ii) there is a limitation in modelling variation in taste among respondents. The first problem, as explained, is associated with the IIA property while the second arises when there is taste/preference variation among respondents due to observed and/or unobserved heterogeneity. While observed heterogeneity can be introduced into the model by allowing interaction between socio-demographic characteristics and attributes of the alternatives or ASCs, unobserved heterogeneity cannot be handled by MNL models. The way to accommodate unobserved heterogeneity is to use a mixed MNL model and hence overcome the second problem associated with MNL. The first problem of MNL, the homoskedasticity assumption, is relaxed by using the Nested MNL (NMNL) model. As it is explained in the following subsection according to this model's specification, the variance differs between nests but is the same within each nest. Other specifications that account for heterogeneity either assume that error terms are independently but non-identically distributed with scale parameter μ_i (Bhat 1995) or model heterogeneity in the covariance among nested alternatives (Bhat 1997).

However, as emphasised in Hensher *et al.* (2005) MNL still provides the best way of getting to know one's data and it has been found that the statistically significant influences found in an MNL model are often the influences that are retained as the strong conditions of IID/IIA are relaxed. Hence, it is advised that the analyst spends some considerable time before s/he decides to move to a more 'flexible' model and that is the principle that is followed as well in thesis' data analysis.

3.3.2 Nested multinomial logit

There are at least two main ways of accommodating the fact that the IID/IIA condition is violated (Hensher *et al.*, 2005; Train 2009). The first is to try and include in the representative part of utility (V) as much relevant information as possible, which will result in a minimal amount of information in the unobserved component (ε) and hence make the MNL model possible to retain, and the other is to consider a choice model that allows for violation of the above condition. One type of model that relaxes the homoskedasticity assumption of the MNL model is the nested MNL model.

The nested logit is regarded as having a simple functional form and provides many options of possible substitution patterns. In particular, the nested logit is the most widely used member of the Generalized Extreme Value family of models (GEV). The main characteristic that these models share is that the unobserved portions of utility for all alternatives are jointly distributed as a generalized extreme value. Hence, the difference with the standard logit models is that the distribution of GEV models allows for correlations over alternatives and hence these models do not impose the IID/IIA condition. In general, the nested logit is a choice model that recognizes the possibility of different variances across alternatives (that means that IID is relaxed to some extend) and some correlation among subsets of alternatives (IIA relaxed to some extent too). As a result, the flexibility of the NMNL lies in the possibility of the variance of the unobserved component of utility being different across groups of alternatives in the choice set (Hensher and Greene, 2002). Hence, this model acknowledges the fact that it is not possible to capture all sources of correlation over alternatives into representative utility and allows instead the possibility of correlation in unobserved utility.

The different choice outcome across alternatives can mean (besides the fact that variances may be different) that subsets of alternatives may share similar information and hence there may be correlation among pairs of alternatives (Hensher *et al.*, 2005). This flexibility makes the NMNL appropriate when the set of alternatives faced by the individual can be partitioned into subsets, called nests. The nested structure of the model imposes a hierarchy and enables the analyst to model individuals first choosing between subsets of alternatives and second choosing between the alternatives within the chosen subset (Domencich and McFadden, 1975). The first choice made is called marginal choice while the second is called conditional choice as it is conditional on the marginal choice made previously.

This hierarchical choice structure of nested logit model is best visualised with a tree diagram (Figure 3.6) and taking an example from transportation where an individual has to chose between 4 means of transport. Each branch in the tree denotes a subset of alternatives and every leaf on each branch denotes an alternative. In this framework, the compound utility of any alternative is: $U(Alt) = U(Alt \mid Branch) + U(branch)$ and the behavioural implications are that correlation is present among the branches but not among the leaves.

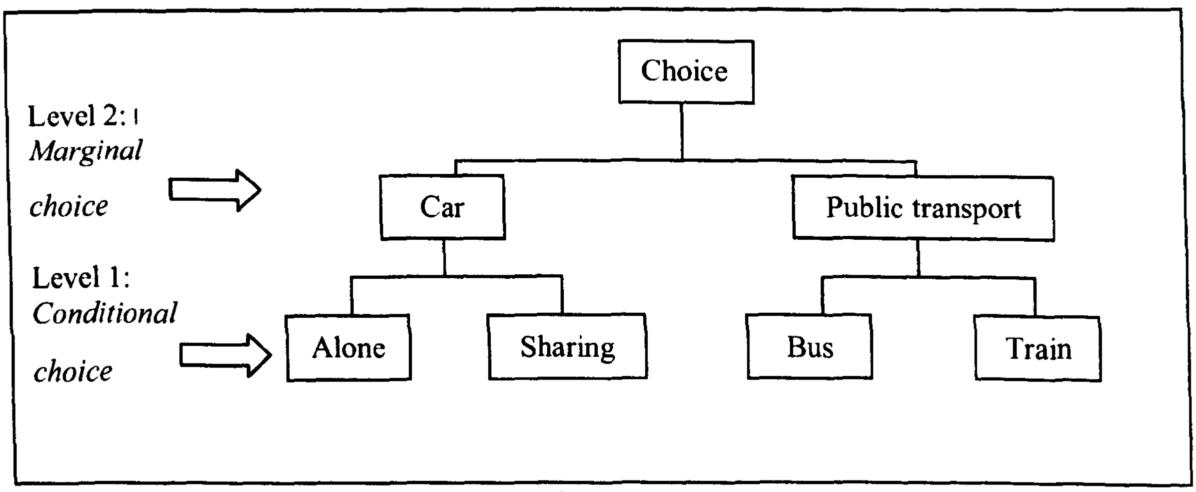

Figure 3.6: Tree diagram for transportation mode

Following Figure's 3.6 two level model, it is observed that nesting creates a set of conditional choices and a set of marginal choices where the individual may first choose between car and public transport (marginal choice) and then given a choice, for example car, may choose among driving alone or ride sharing (conditional choice). Hence, according to the tree diagram the probability of one choosing 'driving alone' is equal to the joint probability of choosing car (*Prob (car)*) and choosing car along with the option of driving alone (*Prob (alone|car)*):

$$Prob(alone) = Prob(car) * Prob(alone \mid car)$$

In a general form, the joint probability is the product of the following two choices in a two level model:

$$Prob[Alt, Branch] = Prob(Branch) * Prob(Alt \mid Branch)$$

The correlation structure for this model is such that although branches have different variances (scale factors), within a branch the variances are identical (IIA applies) and covariance equals variance at higher level.

However, in the case that an individual chooses between all modes simultaneously and choices are independent, the joint probability for example of 'driving alone' is the product of the two marginal choice probabilities, that of the 'car' and that of the 'public transport'. In this case, the nested logit model can be seen as a set of linked MNL models, in our example of two, one for the 'car' and one for the 'public transport'.

Hence, setting out the key relationships for adopting a nested logit model, and following Train (2009) a nested logit model is appropriate when the set of alternatives faced by a decision maker can be partitioned into nests in such a way that IIA holds within each nest but not across nests. Holding these two properties and the fact that the model is consistent with utility maximization, the specification of the model assumes a set of alternatives within choice set S into K nests denoted B_1, B_2,..., B_K. The utility that a person n obtains from alternative g in nest B_k is: $U_{ng} = V_{ng} + \varepsilon_{ng}$, where V_{ng} is observed by the researcher and ε_{ng} is a random variable not observed by the researcher.

The nested logit is derived by assuming that the unobserved utility ε_{ng} for all elements g in choice set S is distributed according to GEV distribution which has the following cumulative distribution:

$$F(\varepsilon_{ng}) = \exp\left\{-\sum_{k=1}^{K}\left(\sum_{g\in B_k}\exp(-\varepsilon_{ng}/\lambda_k)\right)^{\lambda_k}\right\} \tag{3.31}$$

This distribution is a generalization of the distribution that gives rise to the logit model as the marginal distribution of each ε_{ng} is a univariate extreme value but the ε_{ng}'s are correlated within nests. For any two alternatives g and h within nest B_k, ε_{ng} is correlated with ε_{nh} and for any two alternatives in different nests the unobserved portion of utility is still uncorrelated: $Cov(\varepsilon_{ng}, \varepsilon_{nh}) = 0$ for any $g \in B_k$ and $h \in B_l$ with $l \neq k$. The parameter λ_k is a measure of correlation (degree of independence) of the unobserved utility among the alternatives in nest B_k. As a result, a higher value of λ_k means greater independence and less correlation. More precisely, the statistic $1 - \lambda_k$ is used as a measure of correlation that shows that as λ_k rises the statistic drops and when $\lambda_k = 1$ this indicates no correlation within nest k. In this case the nested logit reduces to a standard logit and the GEV distribution becomes the product of independent extreme value terms. Hence, testing the constraint $\lambda_k = 1$, using the LR-test, is thus the same as testing whether the nested logit model is a better specification than the standard logit. In particular, firstly the LL for the NMNL model is found and then the Inclusive Value (IV) parameters are constrained to equal 1. The degrees of freedom of the χ^2 equal the number of branches (Greene 2009).

The model's implied distribution leads to the following choice probability for alternative $g \in B_k$:

$$P_{ng} = \frac{\exp(V_{ng}/\lambda_k)\left(\sum_{h\in B_k}\exp(V_{nh}/\lambda_k)\right)^{\lambda_k - 1}}{\sum_{l=1}^{K}\left(\sum_{h\in B_l}\exp(V_{nh}/\lambda_l)\right)^{\lambda_l}} \tag{3.32}$$

These choice probabilities can be expressed in a simpler and more interpretable way without loss of generality if the observed component of utility is decomposed in two parts: (1) a part labelled W that is constant for all alternatives within a subset/nest, and (2) a part labelled Y that varies over alternatives within a nest. In particular, the utility is expressed as:

$$U_{ng} = W_{nk} + Y_{ng} + \varepsilon_{ng} \; for \; g \in B_k, \tag{3.33}$$

where W_{nk} depends only on variables that describe nest k and can be expressed as the mean of V_{ng} over all alternatives within nest k and Y_{ng} depends on variables that describe alternative g and hence could be expressed as the deviation of V_{ng} from the mean W_{nk}. Following this decomposition of utility the nested logit probability can be expressed as the product of two standard logit probabilities. Let the probability of choosing alternative $g \in B_k$ be the product of two probabilities. As seen previously in the example from transportation, it is the product of the marginal probability P_{nBk} (the probability that an alternative within the nest B_k is chosen) and the conditional probability $P_{ng|Bk}$ (the probability that the alternative g is chosen given that an alternative in nest B_k is chosen):

$$P_{ng} = P_{ng \mid B_k} P_{nB_k} \tag{3.34}$$

P_{ng} is decomposed into a marginal and conditional probability because with the GEV formula for P_{ng} the marginal and conditional probabilities take the form of logits. In particular, these two probabilities can be expressed as follows and after algebraic rearrangement of choice probability P_{ng}:

$$P_{ng|B_k} = \frac{\exp(Y_{ng} / \lambda_k)}{\sum_{h \in B_k} \exp(Y_{nh} / \lambda_k)} \tag{3.35}$$

$$P_{nB_k} = \frac{\exp(W_{nk} + \lambda_k I_{nk})}{\sum_{l=1}^{K} \exp(W_{nl} + \lambda_l I_{nl})} \tag{3.36}$$

where:

$$I_{nk} = \ln \sum_{h \in B_k} \exp(Y_{nh} / \lambda_k) \tag{3.37}$$

As a result, the conditional probability of choosing g, given that an alternative in B_k is chosen, is expressed as logit with variables that vary over alternatives within each nest while the marginal probability of choosing an alternative in nest B_k is also expressed as logit with the variables that vary over nests of alternatives. Furthermore, the term I_{nk} included in the marginal probabilities, expressed as the log of the denominator of the conditional probability, is a utility index that can be interpreted as the average utility that individual n can expect from alternatives within the nest. In other words is the expected utility that decision maker n receives from the choice among the alternatives in nest B_k. This is known as the IV of nest k or logsum or composite cost. Alternatively, in Hensher *et al.* (2005) this index represents the expected maximum utility which is associated with the alternatives that reside within the nest and which are characterised by their observed attributes and also the random components. These latter involve some expectation as to what can be extracted from these random terms for each alternative associated with the composite alternative whose marginal probability is calculated.

It can be shown now that IIA holds within each subset/nest of alternatives but not across nests. Again considering alternatives g and h that both are in subset B_k:

$$P_{ng} / P_{nh} = \frac{P_{ng|\mathrm{B}_k} \cdot P_{B_k}}{P_{nh|\mathrm{B}_k} \cdot P_{B_k}} = \frac{P_{ng|\mathrm{B}_k}}{P_{nh|\mathrm{B}_k}} = \frac{\exp(Y_{ng})}{\exp(Y_{nh})} \quad (3.38)$$

This ratio is independent of all other alternatives other than g and h. However, in the case that the two alternatives are in different subsets/nests that is $g \in B_k$, and $h \in B_l$ for $k \neq l$:

$$P_{ng} / P_{nh} = \frac{P_{ng|\mathrm{B}_k} \cdot P_{B_k}}{P_{nh|\mathrm{B}_l} \cdot P_{B_l}} \quad (3.39)$$

This ratio depends on the attributes of all alternatives in B_k, and B_l but not on the attributes of alternatives in nests other than those containing g and h. This form of IIA is described as 'independence from irrelevant nests' (Train 2009).

Although the above model is described in two levels (level 1 and 2 as in Figure 3.6), there are cases that higher level models are appropriate. Furthermore, instead of capturing correlations among alternatives, the researcher may simply want to allow the variance of unobserved factors to differ over alternatives. This assumption gives rise to the Heteroskedastic Extreme Value (HEV) model which is the same as logit except for having a different variance for each alternative and hence allowing the variances in the utility functions to vary, $F(\varepsilon/\sigma) = exp(-exp(-\varepsilon/\sigma))$. Furthermore, the HEV model can be extended to accommodate the case where variance is different both across individuals (for example variance is allowed to be a function of age and/or gender) and choices/alternatives. Finally, the paired combinatorial logit which is like the nested logit with the exception that it allows g to be in more than one nest completes so far the GEV family. Researcher can generate other GEV models adapted to its needs.

As far as the estimation of the parameters of the nested model is concerned, they can be estimated by standard maximum likelihood techniques. By substituting the choice probabilities into the LL function an explicit function of the parameters of this model is obtained. Furthermore, taking advantage of the fact that the choice probabilities can be decomposed, as seen before, into marginal and conditional probabilities that are logit, nested logit models can be estimated sequentially. Sequential estimation involves estimating first the models for the choice of alternatives within the nest, followed by calculation of the inclusive values I_{nk} for each of these models and finally entering these inclusive values as explanatory variables in the estimation of the model that derives the choice of nest. As argued in Train (2009), although the sequential estimation (limited information approach) of nested logit models is consistent, is not as efficient as simultaneous estimation by maximum likelihood. Therefore the latter should be preferred unless problems arise in the simultaneous estimation called as well full information MLE expressed as (Greene 2003):

$$lnL = \sum_{k=1}^{K} ln[Prob(leaf \mid branch)_k \times Prob(branch)_k]$$

where k is the chosen nest/branch.

An extension of the nested MNL which is still at an experimental stage since it is quite difficult to fit is the Generalised Nested Logit model (Greene 2009). According to this model, alternatives may appear in more than one branch and the numerator and denominator of the choice probability is weighted by the proportion of alternative for example g allocated to branch k. This proportion is modelled as an MNL.

The next model of this section responds to the question of how to model and accommodate heterogeneity which is considered an important issue not to be neglected. As noted: "... economists are often more interested in aggregate effects and regard heterogeneity as a statistical nuisance parameter problem which must be addressed but not emphasised. Econometricians frequently employ methods which do not allow for the estimation of individual level parameters" (Allenby and Rossi, 1999, p.58). Of particular interest for social scientists is the heterogeneity in choice strategy that implies that consumers avoid 'complexity' and adopt simplification strategies eliminating certain attributes. As a result, information processing strategy is a source of heterogeneity in the model that needs attention.

Heterogeneity takes the form of observed heterogeneity that enters in the model in different ways for example in the variances or means of the utility function by scaling, and unobserved heterogeneity that requires to structure the model so that it makes sense ('structural heterogeneity'). The following section presents the so-called mixed MNL model that accounts for this second type of heterogeneity.

3.3.3 Mixed multinomial logit

The mixed logit also called 'random parameter logit', 'mixed MNL' or 'hybrid model' has provided the analyst with improved behavioural specifications. Mixed logit flexibility overcomes the restrictions of logit and probit models. In particular, with regard to the random parameter logit, random taste variation is allowed for, as is unrestricted substitution patterns and correlation in unobserved factors over time. On the other hand, compared to the probit model, the mixed logit is not restricted to the normal distribution.

The mixed logit probability is derived from utility maximizing behaviour and the most widely used derivation is the one based on random coefficients. In this framework, the decision maker faces a choice among M alternatives while the utility of individual n from alternative g is specified as: $U_{ng} = \beta'_{n} x_{ng} + \varepsilon_{ng}$, where x_{ng} are observed variables that relate to the alternative and decision maker and ε_{ng} is an IID extreme value random term. The element that diversifies the mixed logit specification than that of standard logit is that compared to the latest that has fixed βs for all decision makers, the mixed logit allows βs to vary over decision makers in the population with density $f(\beta)$ and parameters θ that represent the mean and covariance of the true parameters of taste distribution, denoted as $f(\beta|\theta)$. The βs have been interpreted as representing the tastes of individual decision-makers and θ as the parameters that describe the distribution of

βs across decision makers. As a result, the standard deviation of βs accommodates the presence of unobservable preference heterogeneity in the sampled population.

As before, decision-maker n chooses alternative g, if and only if $U_{ng} > U_{nh}$ $\forall\, g \neq h$. The researcher in the case of mixed logit observes x_{ng}'s but not ε_{ng} or β_n. If the researcher observed β_n then the choice probability would be the standard logit. However, because that is not the case, the unconditional (on β_n) choice probability is the integral of the standard logit probability $L_{ng}(\beta_n)$ over all possible values of β_n (or density of parameters β_n). More explicitly the choice probabilities of a mixed logit model are expressed as:

$$P_{ng} = \int L_{ng}(\beta) f(\beta) d\beta \tag{3.40}$$

where $f(\beta)$ is the density function of the β parameters and L_{ng} is the logit probability evaluated at parameters β, denoted as:

$$L_{ng} = \frac{\exp(V_{ng}(\beta))}{\sum_{h \in S} \exp(V_{nh}(\beta))} = \frac{\exp(\beta'_n x_{ng})}{\sum_{h \in S} \exp(\beta'_n x_{nh})} \tag{3.41}$$

Since utility is expressed as linear in β and $V_{ng}(\beta) = \beta_n' x_{ng}$, mixed logit probability takes its usual form:

$$P_{ng} = \int \left(\frac{\exp(\beta_n' x_{ng})}{\sum_{h \in S} \exp(\beta_n' x_{nh})} \right) f(\beta) d\beta \tag{3.42}$$

As stated in Train (2009, p.135) "the mixed logit probability is a weighted average of the logit formula evaluated at different values of β with the weights given by the density $f(\beta)$". Mixed logit takes its name because of the fact that the choice probability P_{ng} is a mixture of logits with $f(\beta|\theta)$ as the mixing distribution.

The next step for the researcher is to specify a distribution for the coefficients that satisfies his/her expectations about behaviour in his/her own application context and then estimate the parameters of that distribution. An important consideration for the researcher which is related to the distributional assumptions is the establishment of the appropriate set of random parameters. As Hensher *et al.* (2005) noted, such a task requires apart from the distributional assumptions, consideration of the number (and type) of draws and in the case of multiple choice situations per individual whether correlated choice situations are accounted for. A test to assist the establishment of candidate random parameters is to assume that all parameters are random and then examine their estimated standard deviations using a t-test for individual parameters or the LR-test for testing the overall contribution. However, according to Revelt and Train (2000), the mixed MNL tends to be unstable when all parameters vary over the population as they do not converge in any reasonable number of iterations. Following McFadden and Train (2000), the identification of random parameters can be assisted by the Lagrange Multiplier tests that provide a statistical basis for accepting/rejecting the preservation of fixed parameters in the model.

Selecting the distribution of the random parameters is an important aspect of model specification and a big challenge considering the unknown distribution of parameters. Although the $f(\beta)$ distribution can be discrete, a fact that gives rise to the Latent Class

Model (LCM), in most applications $f(\beta)$ is continuous. Types of distributions that have been employed by researchers include the normal, lognormal, uniform, triangular, and gamma. The lognormal form is often used if the researcher suspects that the taste parameter is either strictly positive or strictly negative, although its very long right-hand tail is a disadvantage for WTP calculations; while the uniform distribution with a (0, 1) bound is preferred when dummy variables are considered. Distributions represent approximately real behaviour as they suffer from deficiencies such as the sign and the length of the tail(s). As such, the spread or standard deviation of the distribution at its extremes may give the 'wrong' sing for some parameters. In order to overcome this limitation truncated or constrained distributions seem to be an appealing solution. Hence, a constrained specification that implies that the standard deviation of each random parameter is a function of the mean is expected to result in more acceptable parameter estimates.

Another way to derive the mixed logit probability from utility maximising behaviour with a different interpretation of random-coefficients is that of error-components. In the case of the latter the mixed logit model can be seen as representing error components that create correlations among the utilities for different alternatives. In particular, utility is specified as: $U_{ng} = a' x_{ng} + \mu'_n z_{ng} + \varepsilon_{ng}$,where x_{ng} and z_{ng} are vectors of observed variables related to alternative g, α is a vector of fixed coefficients, μ is a vector of random terms with zero mean and ε_{ng} is IID extreme value. The unobserved and stochastic portion of utility is captured by the error components z_{ng} and ε_{ng}, which can be correlated over alternatives depending on the specification of z_{ng}. As a result, the model does not exhibit the IIA property and various correlation/substitution patterns can be obtained according to the choice of variables to enter as error components. If the error terms are IID standard normal a random parameter multinomial probit is assumed while if they are IID type I extreme value a random parameter logit model is expected (Alpízar *et al.*, 2001).

The equivalence of the error-components and random-components specifications can be seen if the random β_n tastes of random-components model are decomposed into individual's population mean α and individual's deviation μ_n, so that $U_{ng} = a' x_{ng} + \mu'_n x_{ng} + \varepsilon_{ng}$ with error components $x_{ng} = z_{ng}$. Hence, although error-component and random-coefficient specifications are formally equivalent it is the way the researcher thinks about the model that dictates the specification of the mixed logit. As such, when the researcher is mostly interested in revealing and representing substitution patterns the use of error-components seems mostly appropriate. On the other hand, if the researcher is mostly interested in the pattern of tastes by allowing each variable's coefficient to vary then the random parameters is preferred.

Finally, in the case of panel data where the analyst observes repeated choices by each sampled decision maker, the specification of the model can allow coefficients to enter utility as varying over individuals but to be constant over choice situations for each person. As such, utility from alternative g in choice situation S by person n is: $U_{ngS} = \beta_n x_{ngS} + \varepsilon_{ngS}$ with ε_{ngS} being IID extreme value over time, individuals and alternatives. If a sequence of choices of an experiment consisted of D choice sets is considered, the probability that the person makes this sequence of choices is the product of logit formulas since ε_{ngS}'s are independent over time:

$$L_{nD}(\beta) = \prod_{S=1}^{D} \left[\frac{\exp(\beta'_n x_{ngS})}{\sum_{h \in S} \exp(\beta'_n x_{nhS})} \right] \tag{3.43}$$

The unconditional probability is the integral of this product over all β values and is simulated with the same way as the probability with one choice set. The presence of the product of logit formulas one for each choice set *S*, rather than having just one formula, is what differentiates a mixed logit with repeated choices from one with only one choice per decision maker. The choice probabilities have the same general form:

$$P_{nD} = \int L_{nD}(\beta) f(\beta) d\beta \tag{3.44}$$

Therefore, it is possible to let the coefficients for the individual to vary among the choice situations in the survey, relax the IIA property and allow the error components in different choice sets from a given sampled individual to be correlated. This specification would be valid if fatigue or learning effects in the survey are suspected. Another source that may imply correlated responses across observations that violate the independence of observations assumption is the commonality of socio-economic descriptors that do not vary across the choice situations for a specific individual.

In general, it can be argued that the mixed logit provides more information than a standard logit, considering that the mixed logit estimates the extent to which decision makers differ in their preferences for attributes that characterise the 'good' under question. The fact that the standard deviations of the coefficients may enter significantly, is an indication that a mixed logit provides a better representation of the choice situation than the standard logit that assumes that coefficients are the same for all decision makers. When exploring individual heterogeneity around the mean parameter estimate, an interaction is created between the mean estimate of the random parameter and a covariate. If the interaction is not significant that does not imply that there is no preference heterogeneity around the mean but that there is an absence of preference heterogeneity around the mean on the basis of the observed covariates. These covariates may be individual specific, may be related to the decision context or the complexity of the CE. Furthermore, another specification that mixed MNL models allow is that the unobserved effects are correlated among alternatives in a given choice set. In that case, the model permits correlation of random parameters of attributes that are common across alternatives (Hensher and Greene, 2003). In general the mixed MNL model can accommodate correlation over both alternatives and choice situations, correlation over alternatives and not over choice situations or the opposite, correlation across choice situations but not over alternatives.

As far as estimation is concerned, that is achieved through simulation as the choice probability (P_{ng}) cannot be calculated exactly since the integral does not generally have a closed form. Hence, following Train (2009) the probabilities are approximated through simulation for any given value of θ following the next steps: (1) a value of β is drawn from $f(\beta \mid \theta)$ and labelled β_r with the superscript $r = 1$ referring to the first draw, (2) the logit formula $L_{ng}(\beta_r)$ from this draw is calculated, (3) steps 1 and 2 are repeated many times and the results are averaged. This average is the simulated probability:

$$\check{P}_{ng} = \frac{1}{R}\sum_{r=1}^{R} L_{ng}(\beta^r) \tag{3.45}$$

where R is the number of draws.

Next the simulated probabilities are inserted into the LL function and define the Simulated Log-Likelihood (SLL):

$$SSL = \sum_{n}\sum_{g} d_{ng} \ln \check{P}_{ng} \tag{3.46}$$

where $d_{ng} = 1$ if n chose g and 0 otherwise. The value of θ that maximises SLL is the maximum simulated likelihood estimator.

Following Hensher *et al.* (2005), the selection of the number of points for the simulations is an important model specification issue. The computation of choice probabilities by simulation requires Monte Carlo integration that involves the generation of 'pseudo-random sequences'. As it has been demonstrated, the standard pseudo-random sequences have the disadvantage that they are not spread uniformly over the unit interval and even with 1000 draws they leave noticeable holes in the unit square. Bhat (2000) proposed the Halton sequence where sequences are constructed from number theory in order to achieve more uniformly spread/coverage over the unit interval and hence acquire much more accurate approximations of Monte Carlo integration. In addition, apart from the uniformity of the pattern, Halton sequence requires far fewer draws (for one dimension about 1/10) and it accelerates estimation by a factor of 5 to 10 (Greene 2009). The selection of the number of draws that secures a stable set of parameter estimates varies. In general terms, it is regarded that the number of required draws increases for a given type of draw as the model specification becomes more complex in terms of the number of random parameters, the treatment of preference heterogeneity around the mean and the correlation of attributes and alternatives (Hensher *et al.*, 2005). It is suggested that a range of draws should be used to estimate models and stability for each and every model should be confirmed. The following figure (Figure 3.7) provides a visual representation of Halton sequences *versus* random draws.

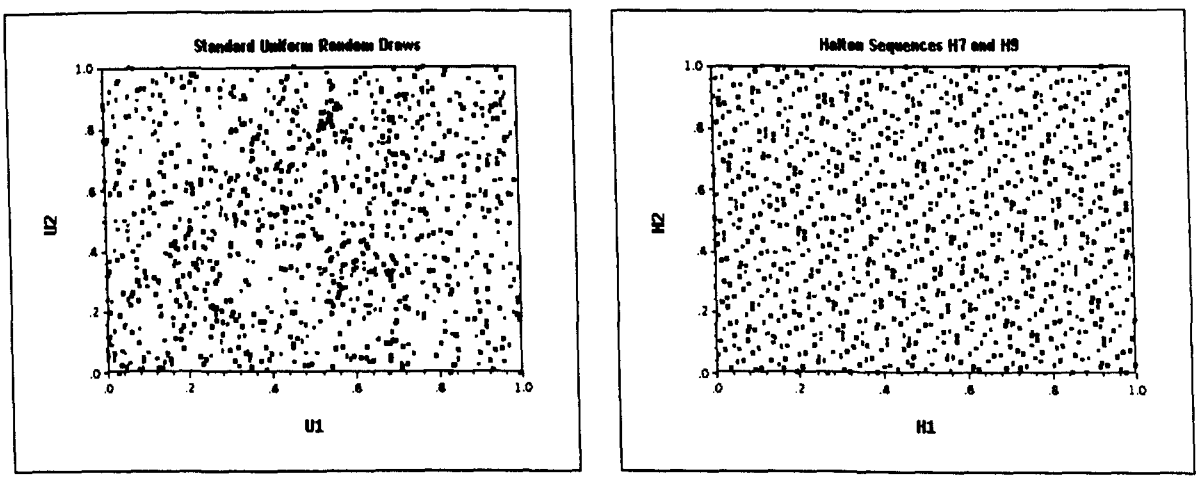

Figure 3.7: Halton sequences *versus* random draws (Source: Greene (2009))

An alternative way of estimation that provides information about θ and each decision maker's β simultaneously is to follow Bayesian procedures. Asymptotically it has been found that the two procedures (classical and Bayesian) produce very similar results.

As referred in Hensher *et al.* (2005), the most recent advance in the application of mixed logit models is that the analyst can construct estimates of 'individual specific preferences' by deriving the individuals' conditional distribution based on prior information that is their known choices. Hence, in contrast to a fully random assignment within the entire sampled population, the conditional parameter estimates are 'same choice specific' parameters and strictly not individual-specific. That means that the analyst identifies a mean and standard deviation estimate for the subpopulation of individuals who, when faced with the same choice situation, would have made the same choices.

Another way of modelling unobserved taste heterogeneity is to use LCMs. These models assume that a number of *a priori* unknown classes exist in a population. In this framework heterogeneity is captured by assuming that the underlying distribution of tastes can be represented by discrete distributions. Small (finite) number of mass points can be interpreted, as different groups or segments and preferences are homogeneous within each (latent) unobserved class, thus heterogeneity is across classes. As such, differences in preferences are conditional on the probability of membership in a latent class. Class assignment is probabilistic determined by individual characteristics and each individual is member of only one class while within class the choice is characterised by the IIA property. In addition, the number of classes is exogenous information and the analyst needs to make the decision as it is not part of estimation. The choice probability is the following:

$$P_{ng} = \sum_{d=1}^{D} Share_d \left(\frac{\exp(\beta_d ' x_{ng})}{\sum_{h \in S} \exp(\beta_d ' x_{nh})} \right) \tag{3.47}$$

where n is the individual, D is the total number of segments in the population, d is number of segment, *Share d* is the share of the population in segment d, g and h the alternatives and xs their corresponding attributes.

As Louviere (2006) noted on LCMs, although they also confound various sources of unobserved variability they seem to fit data at least as well as random parameter models and they deserve more attention till a better way to come around scale confounds is achieved and behavioural theory has progressed in that direction. LCMs adopt a discrete approximation in modelling individual heterogeneity compared to the continuous approach that characterises the mixed logit. Hence, although the latter allows full random variation the former allows limited variation by employing latent clustering. These two types of models although they lead to the same estimator differ in the adopted thinking process.

3.3.3.1 A comment on WTP derivation

As seen earlier in Section 3.2.6 the estimation of WTP values involves taking the ratio between a non-price attribute and the price attribute. However, this standard methodology of calculating WTP may not apply in the case of mixed MNL and in particular when one of the parameters is estimated as random. Such a scenario requires other methods of calculating WTP. Following Hensher *et al.* (2005) one can use all the information in the distribution or just the mean and standard deviation in deriving WTP estimates based on random parameters. Although the former is preferred, it is more complicated and simulation is required, drawing from the estimated covariance matrix for the parameters.

When the population moments are used to derive the WTP distribution each individual is randomly assigned along the continuous distribution without considering any prior information that could indicate a more accurate allocation. In that case the distribution is referred as unconditional (Hensher *et al.*, 2005) and the procedure is such that draws are taken of an attribute parameter and a price parameter from the estimated population distribution of parameters. Their ratio is derived and this procedure is repeated many times (Hensher and Greene, 2003; Hensher *et al.*, 2005). Specifying the cost parameter as fixed and considering formula (3.20) but with $\hat{\beta}_{m,n}$ allows easy derivation of the distribution of WTP, since it is distributed in the same way as the attribute's m parameter (Revelt and Train, 2000) while potential identification problems associated with the choice of a distribution for the cost parameter are avoided.

Following the Krinsky and Robb (1986) procedure and using the Johnson S_b distribution, values for random coefficients are generated and then used for the simulation of the distribution of the WTP. The WTP for an attribute with a random coefficient is simulated as:

$$WTP_m = -\frac{\hat{\alpha}_m + \hat{b}_m \cdot (\exp(y_m)/(1+y_m))}{\gamma} \tag{3.48}$$

where, y_m has a normal distribution $N(\hat{\mu}_m, \hat{\sigma}_m)$ and $\hat{\alpha}_m$, $\hat{b}_m$, $\hat{\mu}_m$ and $\hat{\sigma}_m$ are estimations of parameters of the Johnson S_b distribution corresponding to the estimated random parameter[5].

On the other hand, the fixed cost parameter makes the denominator of WTP smaller than it should be causing overestimation of the mean WTP (Sillano and Ortúzar, 2005). Furthermore, even if the cost parameter is specified as random it does not improve

[5] Note that Johnson Sb distribution is bounded between a and a+b and if y~N(μ,σ), then x=a+b (exp(y)/(1+exp(y)) has a Johnson Sb distribution.

things but on the contrary makes the variance of WTP too large since the ratio tends to have a very large variance and can result in extreme value estimates.

The other way for establishing a WTP distribution is to make use of within-sample additional information on the alternative chosen and allocate each sampled individual conditional to its chosen alternative. This approach (by applying Bayes' theorem) provides us with more behaviourally accurate distributions of WTP (Hensher *et al.*, 2005) as they are derived from common-choice-specific parameters from a subpopulation of individuals. In particular, following Bayes' rule the conditional choice probability is:

$$H_{ng}(\beta_n \mid \theta) = \frac{L_{ng}(\beta_n) g(\beta_n \mid \theta)}{P_{ng}(\beta_n \mid \theta)} \quad (3.49)$$

where $L_{ng}(\beta_n)$ is the likelihood of an individual's choice if s/he had this specific β_n, θ is the set of parameters in the underlying distribution of β_n, $g(\beta_n \mid \theta)$ is the distribution in the population of $\beta_n s$, and $P_{ng}\ (\theta)$ is the choice probability function defined in open-form as:

$$\mathrm{H}_{ng}(\theta) = \int_{\beta n} L_{ng}(\beta_n) g(\beta_n \mid \theta) d\beta_n \quad (3.50)$$

Hence, by using (3.49) and (3.50) the expected value of the ratio between the attribute parameter estimate and the cost parameter estimate is derived, so that the individual-specific associated mean and standard deviation indicators of WTP are a more appealing approximation of the true values, avoiding at the same time the complex issues described above.

3.4 Chapter summary

In this chapter, an extensive overview of the theoretical background and econometric properties of discrete choice experiments were provided, while its main objective was to provide the background for the analysis to follow in the next chapters in order to reveal respondents' preferences and elicit their WTP for improvements in river water quality due to the EU WFD. Consequently, chapter started from a presentation of the theoretical foundation of CEs that lies in Lancaster's microeconomic approach, utility maximising behaviour and random utility theory. Initially the focus was on the MNL model which remains a major input in the modelling process, helping to ensure that the data are clean and that sensible results (*i.e*,. parameter signs and significance) can be obtained from models that are not 'cluttered' with complex relationships (Louviere *et al.*, 2000). In addition, special emphasis was put on the role of scale which requires more the attention of researchers. Then the other two most commonly employed specifications of discrete choice models, used to analyse respondents' preferences and to elicit their WTP, the NMNL and the MMNL were presented.

4

DEVELOPING THE QUESTIONNAIRE AND DESIGNING THE SURVEY

4.1 Introduction

This chapter describes the different stages that are needed in order to set up a discrete CE questionnaire. Hence, after introducing the two case studies it shows how the questionnaire and the survey evolved through consecutive steps and relevant decisions. This lengthy process of testing and designing will be explained in order to reveal how they contributed to the final survey mode for the valuation of improvements in the two rivers.

After the case studies' special characteristics presentation, the focus is on the design of the valuation scenario. Starting from the selection of benefits to consider, the chapter evolves through the process of attribute selection and assignment of levels that involved a literature review, consultation with experts, focus groups and a pilot survey. The main concept of selecting the indicators of rivers' quality was to merge WFDs river quality elements for the classification of ecological status with people's perceptions. In the same section visual tools, like show cards explaining river attributes and their levels, as well as maps for geographic reference are exposed.

In Section 4.4, the main elements of the questionnaire are introduced and explained. The questionnaire starts with a section that attempts to reveal familiarity with the rivers and recreational activities undertaken in the local river of interest. Then the valuation scenario is introduced followed by the choice cards. The last two questionnaire sections include the follow-up questions and finally the socio-economic characteristics.

In Section 4.5, the employed experimental design is commented along with decisions that are related to its application. Section 4.6 discusses decisions related to the survey design, such as which should be the target population, what is the preferred survey mode, and what is the applied sampling strategy. Finally, a brief summary of the chapter is offered in Section 4.7.

4.2 Case studies

The rivers that were chosen for the study are the Boyne and the Suir. The first belongs to the Eastern River Basin District (ERBD) while the second belongs to the South Eastern River Basin District (SERBD). The following figure (Figure 4.1) presents the geographical location of the HAs or catchment areas of the Boyne and the Suir showing that they belong to different RBDs.

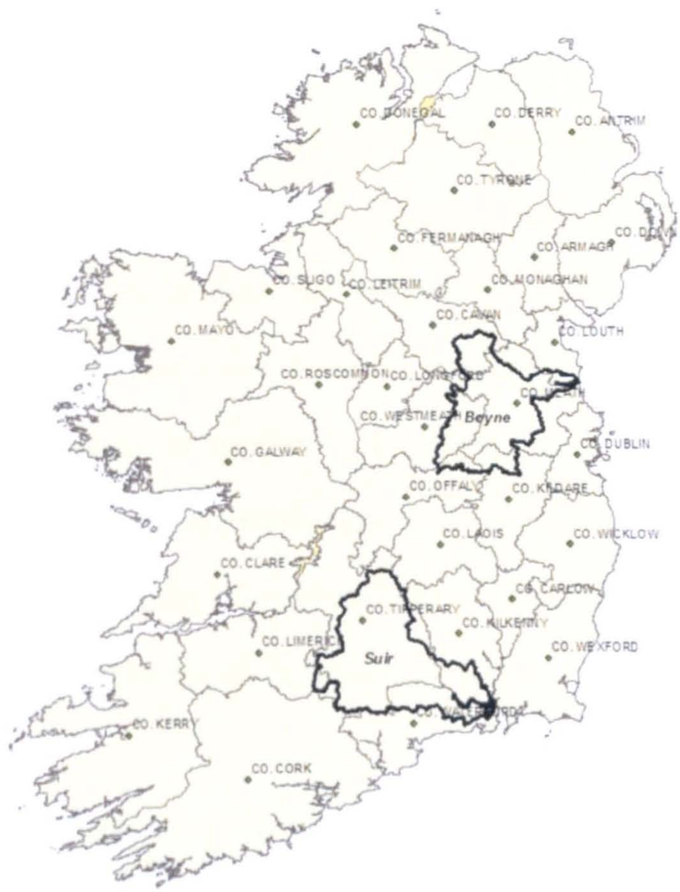

Figure 4.1: Location of HAs of the Boyne and the Suir

A basic criterion for their selection was that rivers should be 'at risk' of failing to meet the GES objective. Additional criteria were that they should belong to different RBDs and be under similar environmental pressures, so that the attributes and levels used were common to both.

These last criteria were dictated by an attempt to test methodological issues related to geographic scope as well as by the objective of attempting a BT for the purposes of the WFD. As such, the two rivers belong to two geographically different areas while sampling of households took place only within the borders of these RBDs. As a result, rivers are not considered substitutes in consumption at least as far as the use values are concerned. This is also verified by analysing replies to the relevant question that asks respondents whether they visit the other river and whether they use in general other river basins for recreation. Following Concu (2007), it is regarded that distance affects the use of environmental goods and services provided, and the information available to the populations/samples, as well as the substitution possibilities. Furthermore, as explained in Chapter 1 and elaborated on later in this chapter, the research design of this study offers the possibility to explore how people, living in the two catchments' samples, trade-off improvements taking place in either or both of the rivers. This becomes possible by presenting respondents with a set of choice cards that includes a location attribute Which River(s) are Improved along with the environmental attributes.

As the initial focus was on rivers that face pollution at a degree that puts them at risk of not meeting the WFD objectives of good water quality, rivers from eastern Ireland were chosen considering information available in the EPA 'Article 5 Characterisation Report' (2005). According to the report, the Eastern RBD, the South Eastern RBD, the Shannon IRBD and the Neagh Bann International RBD have the highest proportion of water bodies in the 1a or 1b risk categories[6], while the South Western RBD, the Western RBD and the North Western IRBD have the lowest proportion of water bodies in the 1a or 1b risk categories. As stated in the EPA report (2008, p. viii): "As expected, the less densely populated, less developed and less intensively farmed regions along the western seaboard have the higher proportions of unpolluted channel while the eastern and south-eastern areas are most affected by water quality degradation". Furthermore, according to another EPA report (2007), the two rivers Boyne and Suir present similar

[6]Irish Reporting Risk Categories coinciding with water bodies "at risk" of failing to achieve an environmental objective

levels of pollution as far as nitrate and phosphate values are concerned which are quite high compared to rivers of the Western and Midlands' RBDs.

For the above reasons, interest was focused on the Suir and the Boyne. In addition, their importance was emphasised in the Three Rivers Project[7] (2003, p.9) that demonstrated that these rivers 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". The same report states that the main channel of the Boyne and the Aherlow River (Suir) are designated salmonid waters under National and European legislation while the whole of the Suir system is possibly one of the best trout systems in the country. However, the same project concludes that the national decline in water quality is reflected in these rivers.

As a result, the Boyne and the Suir rivers are considered as representative water bodies of Ireland where moderate improvements in water quality are likely to be needed to meet GES. A detailed presentation of the two HAs is offered in Appendix A.

4.3 Definition of attributes and levels

The challenging task of attribute selection can be based primarily on, qualitative research (*e.g.,* focus groups) that is tailored to a particular project, secondary research (*e.g.,* literature sources, previous experience with the same or similar products), or (as is most common) on a hybrid approach that uses both secondary and primary research (Adamowicz *et al.*, 1998). In this study, the last approach was followed and in

[7] This three year 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

particular, the attributes in the choice sets were selected following three steps. The first step was a literature review of related studies and policy content, followed by consultation with experts, and finally focus group research. Further adjustments were also made after conducting the pilot study. As has been noted (Powe *et al.*, 2005, p. 515) "the challenge for the researcher is to choose attributes that comprehensively describe the key elements of the scenario, while at the same time ensuring that the experiment does not impose too high a cognitive burden on respondents".

4.3.1 Literature review input

As presented in Chapter 1, the objective of this CE survey was to value the non-market benefits of WFD improvements in river water bodies. As such, the context of valuation did not consider improvements in lakes, estuaries and groundwater. Furthermore, Artificial Water Bodies and Heavily Modified Water Bodies which have different environmental objectives such as that of Good Ecological Potential were also excluded. In order to specify the river related non-market benefits to be valued and hence the attributes to be used in the CE, literature review played an important role. A first view of related benefits was given in Chapter 2 that provided an overview of the economic valuation methods employed to estimate the different components of value associated with water resources.

Blamey *et al.* (1997) referred to four fundamental considerations that arise when attempting to choose attributes and labels for an environmental CM study. The first involves the distinction between the cause of an environmental change under investigation and its effect. A second factor is the level of specificity or detail that is most appropriate, while a third factor that needs to be considered is the extent to which attributes are to be selected according to a demand (what individuals think is important) rather than a supply perspective (what government/scientists think is important). Finally, the fourth consideration is whether to include policy labels or attributes in addition to attributes directly describing the environmental good in question.

In this study, deciding on the selection of the relevant attributes of the non-market good, which is the quality of surface inland water, specifically rivers, two main criteria were considered; on the one hand, people's preferences for a river's ecological status and on the other hand attributes that can be impacted by the implementation of the WFD. Those criteria imply attributes that are meaningful to respondents and relevant for policy. Hence, in this study the aim is to use indicators of ecological status, which ordinary people see as important, but which are also consistent with regulator's expectations about the scientific interpretation of this concept. At this point, it should be noted that another selection criterion that was also considered was to minimise the interdependence between the attributes, although interdependence is a common feature of environmental systems (Van Bueren and Bennett, 2004). In order to achieve that, emphasis was put more on the effects of degradation in river systems rather than on the causes. However, regarding interdependence it has been argued that what is important is that respondents perceive attributes as independent. Furthermore, this issue was tested and further considered during the selection and construction of the experimental design by introducing restrictions, as will be explained in Section 4.5.

In particular, following the literature review results of studies that have used CE to estimate the value of improvements in river quality, benefits are a mixture of use and non-use values. An argument supporting use values could be that preferences are better formed and hence easier to assess compared to non-use benefits, such as improvements in a river's biodiversity which is not necessary related to recreation or amenity values. Considering the attributes used in studies that have employed CE to value improvements in rivers' environment, as presented in the Chapter 2 literature review, it is obvious that ecology, as expected, has a predominant position. However, the studies that have included the parameter ecology in their design have incorporated it in different ways. On the one hand, some studies value ecology as a whole while on the other hand they value individual components of ecology separately, for example the experimental design includes fish as a separate attribute to invertebrates. Other river quality attributes that have been considered in related studies are river banks condition, recreation and aesthetics, although the spatial dimension of the good gains the researcher's interest too.

At this point, it should be noted that even before the literature review the very first stage of the attribute's identification was Annex V of the WFD, which classifies the status of a body of surface water of GES. In particular, according to the WFD the quality elements for the classification of ecological status, as far as rivers are concerned, are biological, hydromorphological, chemical and physico-chemical with the last two supporting the first. In particular, composition and abundance of aquatic flora as well as of benthic invertebrate and fish fauna are included in the biological elements while, in the hydromorphological elements issues of water flow, connection to groundwater bodies, river continuity, depth and width variation as well as structure of the river bed and riparian zone are considered. Finally, the last category involves among others, thermal, oxygenation and nutrient conditions, salinity acidification status and specific pollutants by all priority and other substances identified as being discharged in the body of water.

4.3.2 Consultation with experts

By consulting river basin management planning experts of the HAs of interest, it was confirmed that the ecological status will be assessed considering fish, invertebrate and macrophyte elements while the physico-chemical and hydromorphological elements are regarded as supporting the biological elements. Another way to see the dependence, as one of the EPA experts defined, is to think of physico-chemical analysis measuring the causes of pollution and biological analysis measuring the ecological effects of pollution. As a result, one of the non-market benefits considered from the beginning was exactly the provision of improved ecosystems as the assessment of the ecological status of the rivers focuses primary on biological quality elements. In particular, the elements of ecological status to be considered by experts for WFD implementation in the catchment areas are presented in Table 4.1, along with the parameters that define them.

Table 4.1: The biological quality elements for the assessment of ecological status

Element	**Parameters**
Fish	Composition, abundance and age structure
Macrophytes	Composition and abundance of aquatic flora
Invertebrates	Composition and abundance of benthic fauna

The experts, river managers and ecologists that were consulted were those directly involved in the establishment of the RBDs and River Basin Management Plans. That is the RBD Co-ordinators for the Boyne and the Suir, the relevant consultancies that contributed to the development of the management plans, scientists from the EPA responsible for each HA and the Teagasc scientist on water matters.

In particular, the experts, contacted early 2008, were initially presented with a questionnaire that among other things requested that they identify the indicators of ecological status that they would choose for a project that could help the Boyne and the Suir respectively to meet the objective of GES. Then they were asked to rank the indicators in terms of importance and they were asked to provide levels of the selected attributes with reference to the current and future status.

Already existing classifications available through EPA reports also helped to identify the relevant attributes and levels. In particular, EPA Q-Value classification along with consultation with the river ecologists and managers was the main guide in the initial consideration of attributes. As a result, the pre-focus group stage revealed three main attributes, as presented in the following table (Table 4.2).

Table 4.2: Preliminary attributes (pre-focus groups)
Ecological indicator (fish, invertebrates, macrophytes)
Aesthetics appearance
Improved conditions for recreation

The first attribute, which is in accordance with the WFD and experts, represents the ecological status in terms of fish, invertebrates and macrophytes. It remained to see how this indicator was perceived by the public. In previous surveys' focus groups its different elements were merged under the ecological indicator (for example in Hanley *et al.*, 2007) while in other cases they were considered separately (for example in Kataria 2009).

The recreation indicator was chosen as it represents a use value such as improved opportunities for recreation; for example scenic walks, fishing, *etc.* As it has been reported, "an increasingly significant economic benefit from water is its value for recreation, aesthetics, and fish and wildlife habitat. Water quality is a significant component of recreational and aesthetic enjoyment of water in its natural surroundings, so measuring benefits of water quality improvement activities is also an important issue" (Young 2005, p.271). In terms of geographical attribute scale reference, recreational activities take place mainly at the main channel of the river where access is possible rather than at tributary rivers that are adjacent to farmland. Only fishing may deviate from that rule. Furthermore, it should be noted that the improved conditions for recreation did not imply that access would change directly under the WFD. The last attribute to be considered at this stage was that of appearance, which served as proxy for pollution having an impact on water clarity, algae growth and possibly odour.

The selection of attributes was also in line with issues of concern raised by respondents as summarised in the report of the Heritage Council (2004) 'Seeking your views on water quality'. Three main issues were identified: water quality, pollution, and habitat. In particular, water quality was related to drinking water, recreation, commercial uses and aquatic life forms. Pollution related to waste disposal issues, agriculture and eutrophication and habitat related to aquatic habitat, peat bogs, wetlands and landscape features.

The overall aim of the consultation was to help shape the agenda for later focus group discussions, identify a preliminary set of attributes but also extract background information for each HA to be used in the valuation scenario of the questionnaires. As far as the next step in the identification of the attributes is concerned, the aim was to find out how relevant these indicators were from HAs' residents perspective.

4.3.3 Focus groups

An important step in the refinement of the attributes and levels of the choice sets as well as of the background information (pressures and measures) for each catchment was the contribution of focus group discussions that included direct questioning and cognitive interviews. The input of focus groups was necessary to identify the aspects of river's ecological status that are important to the residents of the catchment.

Because of the difficulty in obtaining a representative sample of the population within a small group of people and as the prime objective for establishing these focus groups was to elicit qualitative information, a convenience sampling approach was followed and not a probabilistic one. In particular, as has been emphasised, "an important goal of the focus group process is to get a sense of the diversity of experience and perception, rather than to get a representative sample *per se*" (Fowler, 1995, p.107). This is quite important when the aim is to survey residents of different age, gender, occupation and from rural and urban surroundings that are expected to perceive differently river quality issues.

In particular, convenience samples were contacted in each HA. Focus groups took place in May and June 2008 in Clonmel, for the Suir catchment, and Navan for the Boyne catchment. Both towns have proximity to the corresponding river and hence local attitudes and current uses were investigated. The number of focus groups was limited to two due to budget constraints. However, it is regarded that focus group contribution coupled with lengthy consultation with experts and cognitive interviews with other potential survey participants, provided all the necessary information.

The sizes of the groups were six and nine people respectively for the Suir and the Boyne. Community groups were primary contacted allowing for homogeneous participants and smooth flow of discussion while the criterion for 'within group' selection was to keep the groups as diverse as possible in terms of age, gender and occupation. In addition, the degree of familiarity to the 'good' varied, as users and non-users participated, as well as the mixture of rural and urban residents. The meetings lasted up to two hours and a money incentive of €25 was offered to each participant for their time and contribution. Two people moderated the groups, one leading and a second assisting by prompting were necessary and taking notes. Both conversations were audio tape recorded.

A predefined focus group technical discussion guide was prepared accompanied by PowerPoint slides. Krueger's (1998) guide for developing questions was followed in order to be clear and ask questions in a conversational manner. Different types of questions were asked such as introductory and key questions, allowing for different time allocation according to importance. The discussion started with an introduction that provided the participants with information such as the discussion being tape recorded, that names would not be attached to any report, the name of the sponsor, the objective of the study, and that there were no right or wrong answers. The focus group discussion was divided in three main parts. The first part included questions that had as their objective an examination of the perception, knowledge and attitude of the participants as well as their understanding of the current environmental situation in the respective river. Furthermore, in this part maps to be included in the main survey were presented and tested for their applicability as visual tools.

Main perception findings during focus group interviews were that participants did not consider the environmental condition of estuary and tributaries separately to the main channel when asked about the scale of improvements. In addition, they expressed the opinion that the catchment suffers from pollution and that they were interested in enhancing its condition.

The objective of the second section of the focus group interviews was to check the understanding of participants of the attributes to be used in the CE, the relative importance of the attributes, the terminology and the visual tools. In particular, emphasis was placed on wording of attributes and levels as sensitivity on definitions can really affect the results[8].

A PowerPoint presentation which consisted of 'information slides' on the different river attributes to be included in the choice sets was used. Different options of wording and visual presentation for attributes and levels descriptions were offered to participants. Afterwards, participants were asked to choose their preferred way to describe improvements. In addition, participants were asked to rank the attributes from most important for consideration to least important and to reveal any other attributes not mentioned that they thought to be important and that needed to be taken into consideration as well. Participants were also asked to reveal the activities they pursued in relation to the river and if they were going to use the river more if its quality was to be improved. Finally, the last question of this section concerned their WTP for such improvements and it attempted to reveal the most suitable payment mode, range of contributions and reasons for zero amounts.

[8]Slovic *et al.* (1977) report the results from studies that have tested the effect of variations related to this issue.

The main findings of the second section were that participants thought that the suggested attributes described fully river's health and only small adjustments were suggested as necessary in the wording. However, a piece of important feedback was that respondents noted that river bank's condition should be added as well to the group of attributes. Other suggestions were to make use of the term 'river life' instead of 'biology' or 'ecology' and they rejected pie or bar charts in favour of photos manipulated in Photoshop and illustrations to show changes. Finally, they strongly expressed their disbelief about payments made to public bodies mainly because of mistrust to authorities while some of them suggested that government should pay for such improvements.

The third part of the discussion dealt with the capability of participants to answer the choice sets. Hence, the appropriate level of choice task complexity was explored. Two versions of the choice sets were presented to participants. In one version, improvements involved one river and in the other, both rivers were to be valued in the same set of choice cards. On average respondents found the overall task "not particularly difficult". The main findings from this part of the interview was that participants thought the presented attributes could interact in some degree with each other and secondly some of them seemed to focus more on one attribute revealing the use of heuristics or cognitive short-cuts. At this point, it should be emphasised again that the main concerns for selecting attributes were firstly that they should be generic in order to be representative of both catchments and allow catchments trade-offs at a macro level and secondly, that they should be perceived as independent by the respondents.

Another interesting finding when participants were presented with both rivers (second version of set of choice cards) was that the 'Suir group' showed an interest in paying for improvements taking place in the Boyne although the opposite was not verified for the 'Boyne group'. Considering all feedback, the post focus group attributes with the respective wording (presented in Table 4.3) was chosen as the 'final' choice (pre-pilot survey) of attributes to be included in the survey with the addition of the attribute 'river bank condition'.

Table 4.3: Post-focus group attributes

Attributes	Type of value
River Life	Non-use value
Water Appearance	Use value
Recreational Activities	Use values
Condition of River Banks	Non-use value

Another step to take prior to fielding the survey was for all images and accompanying wording to be presented to experts and focus groups in order to ensure satisfactory representation of attributes and levels from their perspective. Suggestions were incorporated into the visual cards that describe improvements as well as into maps.

4.3.4 A note on payment vehicle

The monetary cost was the fifth attribute to be included to allow the estimation of WTP. The selection of the payment vehicle is an issue that involves the same concerns as in CVM, such as how credible and realistic it is and if it motivates any strategic behaviour. Following briefly the relevant literature on payments for water/river related improvements it seems that in many cases water rates were identified as a realistic payment mechanism either as an annual environmental levy over a 20 years period

(Van Bueren and Bennett, 2004), as higher water rate payments to a local operator/authority (Hanley *et al.*, 2006a), as an increase in local water rates as part of household's council tax bill (Hanley *et al.*, 2006b), or as extra council taxes per month (Georgiou *et al.*, 2000). A different approach in Morrison and Bennett (2004) is a one-off levy on water rates for all households in the specific catchment along with the assurance that if the household does not pay water rates, an alternative way of collecting the levy would be arranged. A recent study (Baker *et al.*, 2007) used a combination of water bills plus higher prices on everyday products arguing that many actors are involved in improving the water including farms and industry, rather than just water companies. Hence, it was argued that through the 'polluter pays' principle some every day products become more expensive, while increases in household water and sewerage bills will take place too. It was regarded that these payments would be in addition to any payment to ensure no water site gets worse, and would continue indefinitely. As mentioned in Chapter 1, in the case of Ireland, domestic water service charges are foreseen but not yet implemented at a national level.

In addition, input from experts, focus groups, cognitive interviews and pilot testing was used to elicit the most appropriate payment mechanism. Furthermore, participants were asked about the acceptable range of payments. During the first contact with river managers and scientists, the question of financing the measures of improvements yielded different reactions. For example, answers included: "government should pay but not from taxation... mixed shared funding (polluter pays and taxation)... income taxation or local taxation... those who are responsible ... an initial uniform contribution to catchment funds and charging according to usage (for example, number of individuals in the household) providing for wavers for low income families". Concern was even expressed that an income tax may entail a high political cost and there have been cases where respondents showed a preference to national taxation rather than council tax or trust fund as they seem to regard the protection of the environment as the responsibility of the state (Bateman *et al.*, 1995; Bullock and Kay, 1997). Considering all available options the following information was communicated to respondents:

- *The cost would be met through increases in income tax and/or VAT*
- *Assume that any reservations you may have in relation to mismanagement are being properly addressed and that payments will be specifically ring-fenced for improvements happening in the specified river(s)*
- *What is important to consider is that improvements will have a cost for your household for* ***the next 10 years***
- *These payments are in addition to any payments for water usage that you may pay so far*

As far as views on the duration of payments are concerned, they included options such as 'indefinitely, until 2015, until 2027'. Considering the fact that a time span makes decisions about payments easier to relate to and in order to avoid 'protest' answers, a 10-year period of payment was agreed. In addition, a time span until 2015 was not perceived as realistic from participants' point of view.

4.3.5 Assignment of levels

For the assignment of levels, the same steps as above were followed to identify and refine them. In particular, the literature review of Chapter 2 provided an overview of the variety of attribute levels that have been used to describe the attributes considered in this survey.

In general, the levels were assigned to the attributes according to the available information about current status and experts indications. Hence, the baseline for the valuation framework reflected the current situation as described in the Characterisation Report (EPA 2005) submitted in 2005 according to Article 5 dictated by the WFD. In particular, the report provides the firm baseline necessary to plan river basin management for achieving 'good status' for all waters by 2015. The future levels were identified again in consultation with scientists and policy makers along the lines of the WFD.

Specifically, the EPA Q value rating which is in accordance with the WFD levels of GES provided the current and future levels for the River Life attribute, that is Poor, Moderate, and Bad. The levels of other attributes were confirmed and refined during focus groups as they were previously defined in scientist and river managers consultation as well as in the relevant literature. Furthermore, experts were asked to confirm that the various scenario outcomes were feasible.

The range of levels was from two (River Banks attribute) to six (Cost attribute), as presented in Table 4.4 that shows the final selection of attributes and levels. Specifically, for attributes such as River Life, Water Appearance and Recreation, three levels were assigned. The first level coincides with the No Change or *status quo* level, the second is an intermediate stage showing progress and the third reflects GES. It is regarded that the more levels measured of an attribute the more information is captured, making it more likely to identify the true underlying utility function.

Finally, the price vector to be used was chosen considering two sources. Firstly, it was based on previous CVM studies in the UK and EU relating to river improvements; considering at the same time economic parameters that make compatibility suitable to Irish standards, as well as the particular economic climate of the time. Secondly, feedback from the focus groups and pilot survey, through an Open-Ended Contingent Valuation (OECV) question, consolidated the range of prices and verified that it was appropriate. Special consideration was given in identifying the range of the Cost attribute. As noted in Bateman *et al.* (2002), prices that are too low will always be accepted while prices that are too high will always be rejected resulting in a price coefficient which is small or zero. The following table (Table 4.4) presents the final choice (pre-pilot survey) of attributes and levels.

Table 4.4: Final attributes and levels

Attribute	Description	Levels
River Life	Composition and abundance of biological elements (fish, insects, plants)	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

4.3.6 Attributes' and levels visual representation

In order to familiarise respondents with the attributes and their corresponding levels they were presented with show cards describing each of these attributes in accordance with their respective levels. The cards are presented in Appendix B. Illustrations were considered as a preferred means to explain attributes and levels to the respondents. In addition, it was decided to adopt illustrations for all attributes in order to keep representation as consistent as possible and not to bias the respondents in favour of any attribute.

It is worth remembering that attributes and levels were the same for both HAs. During focus group discussions, considerable effort was made to ensure that the images used to portray the improvements were representative of the rivers' environment. In particular, different images were used to reflect not only the attributes but also their levels and as a result, it is regarded that the final choice of images is as closely as possible in line with public perception. The final selection of attributes and levels was also informed and finally confirmed by EPA ecologists in order to conform to the river's environment from a scientific point of view. In the subsequent Subsections 4.3.6.1 to 4.3.6.3, each of the river quality attributes and levels are presented and discussed.

4.3.6.1 River Life

This attribute is regarded as the most representative of GES and is described as closely as possible according to the biological quality index (Table 4.2) current use for assessment of ecological status in HAs. In particular, the index was broken down into elements including fish, macrophytes and invertebrates. The visual card that was employed to represent this attribute was called River Life based on suggestions from focus groups while trying different alternative wordings. Furthermore, participants expressed the opinion that the 'fish, insects, plants' line should supplement the description so people are constantly reminded of what it includes.

The three levels of this attribute (Poor, Moderate, and Good) are in line with EPA and WFD guidelines. In particular, parameters of composition and abundance were used to describe the levels. For example, the 'Poor' level was represented by a limited variety of fish, insects and plants with mainly coarse fish and tolerant species like water hog present. The move towards a 'Moderate' status described a situation where the variety of fish, insects and plants was still reduced and sensitive species like salmon, crayfish, and dragonflies were occasionally present. Finally, the 'Good' level was presented as a condition were fish, insects and plants existed in wide variety and healthy populations of salmon, coarse fish and other sensitive species were present. As previously noted, the wording of the levels was in accordance with the EPA Q – values and WFD guidelines. For example, the 'Poor' level is represented by the EPA Quality Class C and part of D that coincide with Q- Quality Rating Q2-3, Q-3 as employed in the EPA on-line ENVision maps[9]. Table 4.5 shows the correspondence.

[9] http://maps.epa.ie/InternetMapViewer/MapViewer.aspx

Table 4.5: Correspondence of levels with Q – quality ratings and quality classes

Level	**Q- Quality Rating**	**Quality Class**
Poor	Q 2-3, Q 3	Mainly Class C and part of D
Moderate	Q 3-4	Class B
Good	Q 4	Part of Class A

The card of River Life presented in Appendix B contained extra information for the respondents which was communicated through the use of coloured droplets. The purpose of these droplets whose colour coincides with that used in ENVision maps was to give a spatial representation of this attribute within each HA. For that reason, the card on River Life is used in combination with the map of the respective river catchment areas (Appendix C) that showed the spatial distribution of the river and of the attribute. It should be noted that all cards and the map were kept in sight of respondents for as long as the interview lasted.

4.3.6.2 Water Appearance

The attribute of Water Appearance from a scientific perspective represents indirectly the supporting parameter of biological quality, namely that of physico-chemical conditions. As a result, it is regarded that one of the characteristics of river's environment that pollution may affect is water appearance. Different modes to represent this attribute were tried and participants in focus groups found the employed representation more straightforward. In addition, this way of representation does not come into conflict, in a direct way, with the previous attribute of River Life. As noted in Blamey *et al.* (1998) a specific problem that is common in the definition of attributes is the existence of some attributes that are 'causally prior' to other attributes. In order to find out if presumed coexistence of attributes was present the contribution of focus groups was of paramount importance and related feedback was incorporated in the experimental design, as will be explained in the relevant section (Section 4.5). Again, three levels were used to present this attribute, namely: No improvement, Some improvement and A lot of improvement. As shown in Appendix B, the first level was described by low water clarity, excessive algae and possibly bad smell while the next two presented gradual elimination of these negative characteristics.

4.3.6.3 River Banks and Recreation

Although, the River Banks attribute was not identified in the initial group of potential attributes, it was decided to include it as it was strongly suggested by participants in both catchment areas. In addition, it is an attribute that has been employed in the literature to characterise and measure a river's health, and it is also in line with experts' view that improving the condition of river banks is one of the measures that will be applied in order to enhance general ecological status and more particularly in-stream and near-stream ecology. At this point, it should be noted that participants in focus groups were not aware of the interdependence between the condition of river banks and the biological quality, hence they perceived this attribute more from an aesthetic and wildlife perspective.

For the case of Recreational Activities, the levels were described as suggested in focus groups, within the choice sets by drawing a line on the activities that could not be available as presented in Figure 4.2. The actual activities that describe the recreational potential were suggested mainly by the participants and verified after contact with river managers. Respondents to the main survey were also notified that improvements would not affect access to recreation directly.

	No Change	2nd Level	3rd Level
Recreational activities	Walking Boating ~~Fishing~~ ~~Swimming~~	Walking Boating Fishing ~~Swimming~~	Walking Boating Fishing Swimming

Figure 4.2: Recreational activities attribute

It should be noted that the illustrations represent mainly rural stretches of the rivers. That is because those stretches are more representative of the river systems and because it is very likely that the urban stretches are characterised by modifications that may make them reliable to 'good ecological potential 'rather than GES.

4.3.7 A note on the choice of geographic scale

As was pointed out in the Chapter 2 literature review, studies initiated by the WFD have looked at different geographical scales when valuing related benefits. Scale was one of the initial concerns of this study as it is directly related to the targeted population. In this study, HA or catchment area was the geographic scale of reference. It was regarded that this scale seemed more appropriate, considering the interlinked nature of the 'good', as it encompasses the main channel of the river along with its tributaries, which is the whole river system. The guide used in the selection of scale was the WFD, along with communication with experts, other researchers and input from focus groups.

Following the WFD, RBD under Article 3(1) is the main unit for management of river basins while the programme of measures (Article 11) and the objective of achieving good water status should be realised at river basin scale. The WFD also calls for estimation and aggregation of social and agricultural non-market economic benefits at the river basin level. Considering consultation with the experts, and focus groups, it was confirmed that the catchment area (river basin) of each river represents the most appropriate base for developing and implementing water quality management strategies considering the distinct HA special characteristics (river basins within a RBD can differ).

As referred to previously, spatial referencing was achieved by including along with the questionnaire, maps, as shown in Appendix C. These maps provided respondents with information on the geographical distribution of each river system at catchment level. In addition, spatial distribution of water quality in terms of the River Life attribute within the particular HA was communicated with the form of droplets summarised in a pie chart. By presenting respondents with these maps the aim was to inform them about the scale of the study, the location of improvements, their geographical position with reference to the river's main body and tributaries but also about the existence of both catchments included in the valuation scenario. It is regarded that the use of maps makes possible information to be conveyed concisely and to represent baseline environmental status. The maps were designed using GIS software with data representing 2005 values kindly provided by the EPA. The quality index presented is in line with Quality Ratings (Q-values)/Biotic Indexes that are based primary on the relative proportions of pollution sensitive to tolerant macroinvertebrates resident at a river site.

Finally, another contribution of GIS was that it allowed calculating the distance of each household from the closest tributary by matching GIS data, kindly offered by the EPA, regarding river and road distribution with townland information (the smallest Irish administrative division) that respondents provided through the questionnaires. Hence, minimum distance was calculated in kilometres via roadway between centre of townland and the closest road crossing river access. In that way, it was possible to explore the impact of the distance parameter in choice and preference formation.

4.3.8 Piloting the questionnaire

The importance of piloting the questionnaire was paramount and as it has been emphasised, "unless one is relatively certain that subjects understand the goods, understand the market for them, understand the context, *etc.*, it is unlikely that a discrete choice experiment will be incentive-compatible, will provide accurate and unbiased estimates of the tradeoffs and choices ..." (Louviere 2006, p.175). As Hutchinson *et al.* (1995) also pointed out, focus groups and piloting surveys give the possibility to the researcher to identify the desired level of information and context to be provided. Pilot testing of the survey instrument was conducted in the field by the market research agency TNS mrbi in May and June 2009 and involved 48 (24 for each catchment) pilot face-to-face interviews with respondents chosen by probabilistic random sampling from both HAs. The approach that was adopted was that of cognitive interviews which as suggested by Dillman (2007), are indispensable in order to improve most questionnaires. According to this approach, the interviewer asks the respondent to think aloud as s/he goes through the draft questionnaire and tells the interviewer everything s/he is thinking. Finally, the pilots served also to estimate the prior parameters to be used at a later stage in the experimental design.

All respondents who took part in the piloting study completed eight choice cards. The overall feedback from the pilot survey was positive. Respondents seemed to have no major difficulties with the questionnaire and most importantly with answering the choice tasks. However, some respondents had a strong reaction towards paying for any improvements. In particular, 29% of participants in the Boyne catchment and 37% in the Suir catchment consistently chose the *status quo* option from which about half were protesters. Another issue that had to be addressed was the length of time required to complete the questionnaire, which ranged between 35 and 45 minutes. Due to concerns about the cognitive burden that such a lengthy questionnaire would bring to the respondent, as well as due to budget constraints, the questionnaire had to be adjusted to take between 20 and 25 minutes to complete. As a result, questions with less impact on the research's main objectives were eliminated.

The feedback from all stages of pretesting (experts' consulting and review by knowledgeable colleagues, focus groups, pilot study, and cognitive interviews) was used to update and finalise the questionnaire, which was then ready to be distributed to the targeted populations within the two HAs.

4.4 Questionnaire elements

This section gives an outline of the survey questionnaires employed in the Boyne and the Suir catchments. Appendix D presents the full text of the Boyne questionnaire.

According to Dillman (2007), it is important to think of questionnaire design as an attempt to reduce non-response and reduce or avoid measurement error. Although the first issue is related more to implementation procedures, the second is related to a respondent-friendly and interesting questionnaire that keeps both the wording and visual appearance of questions simple. Hence, during the questionnaire design special concern was given to minimize fatigue from questions especially preceding the choice tasks.

It should be stressed that two versions of the questionnaire were used; one for each catchment, with choice cards sharing the same attributes and levels as well as the same information on pressures and measures to improve conditions. The only important difference was that the first four choice cards concerned the local river of each sample. In addition, the behavioural and belief questions at the beginning of the questionnaire referred to the respective local river. For example, in the Suir sample respondents were asked about the type of recreational activities they partake in at the river, the frequency they visit the river, the miles they travel to get there, if they visit rivers other than the Suir and how they describe the general environmental quality of the river. Hence, the Suir questionnaire differed from that of the Boyne questionnaire (see Appendix D) with regard to: (i) the design used to produce the choice cards and (ii) Section A question Q.A1 which referred first to the Suir and then to the Boyne and questions Q.A2 to Q.A8 which referred to the Suir instead of the Boyne.

It is thought that the careful questionnaire design, the contribution of focus groups, cognitive interviews, consultation with experts, the face-to-face survey mode and the follow-up questions, have limited the possibility of potential measurement error resulting from poor question wording or questions being presented in such a way that inaccurate or uninterpretable answers are obtained (Dillman 2007). In particular, the questionnaire consisted of the following sections:

Introduction: Interviewers after introducing themselves to the respondent explained the purpose of their visit. They made explicit that they were conducting a survey in the area on behalf of the University of Stirling in the UK, about the environmental quality of two Irish rivers, the Boyne and the Suir. Information then was given about the length of the interview and respondents were assured about confidentiality issues.

Quota controls: In order to ensure a representative survey sample relative to the catchment areas, respondents were initially asked a few questions to determine their age, gender and occupation. The interview continued, providing that the respondent fitted the interviewer's quota control matrix.

Section A, General attitudes and activities: Respondents were initially presented with the maps of both rivers to inform them about the case study areas. Then their familiarity with each river was explored. In particular, they were asked what they knew about each river allowing for multicode answers. Those respondents who chose the option "visit or have visited the river" for their local river were asked to state approximately how many trips/visits they had made to partake in specific recreational activities during the last 12 months. In addition, they were asked the distance in miles that they had to travel from their home to get to the river on the last occasion that they visited their local river. This question about recreational activities referred only to the local river of each sample. However, respondents were given the chance to state if they visit any other river apart from their local river for recreational purposes. The final two questions of this section asked respondents to describe the general environmental quality (water and surroundings) of their local river by using a 7 point likert scale ranging from 'Very satisfactory' to 'Very unsatisfactory'. Finally, respondents were asked if they were aware of any specific water related policy taking place in Ireland at the moment or in the past, in order to see how informed they were on the particular subject.

Section B, Valuation scenario of rivers' quality characteristics: This section included two different sets of choice cards. Each set comprised of four choice cards. Both sets shared the same environmental (River Life, Water Appearance, River Banks), social (Recreation) and monetary attributes. The difference was that the second set included one extra attribute which was Which River(s) are Improved. This attribute of geographical scope had four levels: None (*status quo*), the Boyne only, the Suir only, and Both. The ordering of the two different choice sets was not altered but remained the same for both samples with the improvements involving only the local river presented first followed by improvements happening in either or both of the rivers. It is understood that there may be a risk of ordering bias however, it is suspected judging by reactions gauged during focus groups and cognitive interviews that this should not be an issue. One way to test the potential ordering bias would have been to develop two versions of the questionnaire, one with the local river first and another with the local river second. However, this strategy would have required a bigger sample size which was not achievable due to budget constraints. Furthermore, rotating the sets of choice cards would have put more stress on interviewers who had already to cope with visual material, four versions of sets of the choice cards and other concerns. Another important element to consider was that respondents were informed beforehand that they would be presented with two different sets of choice cards.

At the beginning of the valuation scenario the respondent, who was looking at the maps throughout the interview, was informed about the pressures in both rivers and the possible measures that could tackle these issues. Respondents were informed from the beginning that they would be asked about improvements in both rivers but in a different context. Furthermore, it was explained that households in both catchments would be asked to contribute when improvements took place in both rivers, while when improvements were unique to the local catchment area, only local households would be asked to contribute. This clarification was regarded as important since it is argued that people consider payments conditional on factors such as 'who else is paying', and 'what is the overall cost of the investment', *etc*.

In addition, since participants in focus groups expressed strong disbelief regarding how the money would be spent, the following text was read to respondents: "*Assume that any reservations you may have in relation to mismanagement are being properly addressed and that payments will be specifically ring-fenced for improvements happening in the specified river(s)*". Furthermore, respondents were asked to consider that these "*payments are in addition to any payments for water usage*" that they may have paid so far.

Then respondents were acquainted with the four attributes employed to describe river improvements. This was enhanced by providing them with show cards, as presented previously, that the interviewer read, allowing time for them to examine the card on their own. When respondents had fully familiarised themselves with these attributes they were shown an example of a choice card with three options and were told that it represented improvements to happen in their local river. The interviewer talked through the choices in order to explain better the choice card and then asked the respondent to make a choice to test that s/he understands it properly. An example of such a choice card is given in the following figure (Figure 4.3).

	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 your household for the next 10 years	€0	€5	€80
Which do you like best?	☐	☐	☐

Figure 4.3: Example of a choice card concerning the local river

Respondents were reminded that they should consider each of the eight choice cards separately and treat the options presented as if they were real and the only ones available, that there were no wrong or right answers and that if they thought that the amount of money was too much to simply choose the No Change option.

Furthermore, a script was included. According to Carlsson *et al.* (2005) a script can significantly decrease the degree of exaggeration and hypothetical bias in stated WTP elicited through CEs. In particular, the text was the following:

"Finally, we would like to mention that some people say 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.

For this reason, please consider:

- *The impacts on you and your family of improving river(s) quality*
- *Imagine your household **<u>actually paying</u>** the amounts specified **<u>for the next 10 years</u>***
- *Consider that your household payments and income may change in the future*"

Having completed the first four choice cards, respondents were asked two related follow-up questions. The first question aimed to reveal any non-trading behaviour for some attributes. In particular, the respondent had to state whether they had ignored any of the attributes of the task. The second question asked respondents to rank the attributes involved in the choice tasks from the one they considered should be given the highest priority to the one they considered should be given the lowest priority in order to assess the consistency and validity of the WTP results.

Section B evolved with the last four choice cards that concerned improvements taking place in the Boyne, the Suir or in both rivers. An example was presented prior to the choice cards (Figure 4.4) and the interviewer emphasised the inclusion of the extra attribute. As before, choice cards related follow-up questions were asked and adjusted to the new context.

	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
Which River(s) are Improved?	None	Boyne	Both
Increase in annual tax payments by your household for the next 10 years	€0	€5	€80
Which do you like best?	☐	☐	☐

Figure 4.4: Example of a choice card regarding the location/catchment attribute

Section C, Follow-up questions: This section included questions of a more general nature that aimed to capture further information that would explain respondents' thought process and reasoning reflected in their choices. In particular, the first question of the section had as an objective the measurement of cognitive ability or burden of respondents through a 7 point likert scale asking how difficult they found it to concentrate, remember information, think logically and clearly and choose the best option. It is regarded that joint performance concerning these skills provides an indication of cognitive ability. The next group of follow-up questions presented respondents with statements that they had to confirm or reject in a 'true' or 'false' context. The scope of these questions was to test if respondents understood the valuation scenario ("The payment concerned improvements in the stretches of the river(s) that are the closest to me"), if they behaved 'rationally' from an economics' theory perspective ("I chose the option that I thought was right given the improvements, the river(s) involved and my available income" and "When deciding on the payment I fully considered what I would have to forgo in order to afford that payment"), or if they employed a different decision rule such as:

"I chose by only trusting my hunches"

"I chose the option thinking what my family and friends would expect/like me to choose"

"I chose the option most likely to happen as I think most of the people will choose that too"

In addition, the following statements offered the chance to explore whether payment related issues influenced their decision-making:

"When deciding on the payment I was thinking of the overall cost of these improvements"

"When deciding on the payment I was thinking who else was going to pay for the improvements"

The last follow-up question that was addressed to all respondents was a CVM question that employed the use of the payment card (Cameron and Huppert, 1989) to elicit WTP for river attributes reaching their best potential as far as the local river was concerned. This section ended with a number of statements directed at those who had consistently chosen the No Change option, designed to distinguish the protest bids from true zero WTP. In this context, respondents were asked to identify the main reason or reasons that justified their choices.

Section D, Socio-economic characteristics: This last section of the questionnaire collected socio-economic characteristics that can influence WTP. Questions focused on years of residence on the area, family size, number of dependents, employment status, involvement in environmental or recreation clubs, own perceptions about having environmental consciousness, educational status and finally level of income. The age of the respondent was asked at the very beginning of the questionnaire when checking quotas.

Other information collected was the county of residence and the townland's name. The latter is the smallest scale of geographical location that could be achieved since postal codes do not exist. The purpose of collecting this information was to explore whether proximity was a key determinant of choice regarding environmental improvements.

Finally, in order to deal with the issue of non-response, which is considered an important source of survey error, an effort was made to collect information on non-respondents. As Fowler (2002, p.56) argues, although non-response rate is not the sole indicator of data quality, "when response rates are high there is only a small potential for error due to non-response to be important. When response rates are low critics of the survey results have a strong basis on which to say the data are not credible".

4.5 Experimental design and choice sets

As has been stated, the choice cards included in the questionnaire are based on an underlying experimental design. As such, the importance of the experimental design is catalytic. One can think of a choice card as a table of numbers with desired properties such as efficiency. Hence, based on a selected design the survey is composed and the outcomes of the survey are used to estimate the model parameters.

As noted in Bliemer and Rose (2006, p.5): "an experimental design describes which hypothetical choice situations the respondents are faced with in the stated CE". Louviere (2006, p.177) emphasises that, "researchers should recognize that the designs chosen for discrete choice experiments are at least as, if not more important than, the models that one uses to analyze the resulting data". Before determining the best experimental design to use, some design related decisions need to be made.

The first step in creating a CE is the model specification with all parameters to be estimated. Hence, based on the model specification the experimental design type is selected and the design generation follows. A starting point of model specification is to capture as best as possible the systematic component of utility that describes the product's attractiveness through its attributes. The ability to capture this component depends on how well the researcher identifies measures and includes as many of the key factors that influence choice as possible. As a result, sufficient time and resources must be devoted in advance of data collection and modelling to identify and include as many of the key influences on choice as possible. However, deciding on the number of attributes to be used for describing each alternative should be seriously considered as there is often a trade-off between including all relevant attributes and complexity that is translated in increased cognitive demand and difficulty in terms of the effects that can be estimated (Blamey *et al.*, 1997). The same is true for choosing the number of alternatives/options to include in each choice set.

As explained in the previous sections, following WFD guidelines, the literature review, focus groups and consultation with experts, specific choices were made concerning the attributes' selection. However, it should be noted that the larger the number of attributes and levels per attribute, the larger the experimental design would be. By making use of statistical experimental designs, subsets of the total set of possible alternatives are selected for use in the questionnaire, since it would not be possible to ask respondents to consider simultaneously all possible alternatives.

Whether attributes are generic or alternative-specific is also an important decision. As already confirmed, in this study's design the alternatives were not labelled with a policy name as the experiment focused on estimating values for attribute changes rather than the stages or processes to achieve the desired outcome of GES. Hence, the alternatives included in the choice set belong to a general class of good or service such as water quality. Blamey *et al.* (2000) argued that although using alternative-specific labels may help respondents to base their choices on the true policy context and hence increase predictive validity and reduce cognitive burden, the generic labelling approach may provide better information regarding trade-offs among attributes, since respondents may be less inclined to base their choices wholly or largely on the labels. As a result, more informed, deliberated and discriminating evaluations are achieved (Blamey *et al.*, 1997). Furthermore, Hensher *et al.* (2005) argues that all other things being equal, unlabelled experiments would tend to require smaller designs while they make possible using the estimation of both linear and non-linear effects. Regarding the choice between generic or alternative specific form, Blamey *et al.* (2000) compared the two approaches in the context of a CM study of the values of remnant vegetation in the Desert Uplands of Central Queensland and found a difference in the cognitive processes generated by choice models using different approaches.

Another important design issue in the current study was the inclusion of restrictions in order to take account of possibly incompatible attribute interactions as perceived by respondents and suggested by experts. In particular, the following restrictions were incorporated in the design:

- River Life is Good and Fishing and Swimming is not possible
- No improvement in Water Appearance and all the Recreational Activities are possible
- No improvement in Water Appearance and River Life is Good

A further restriction was for the None level of the Which River(s) are Improved attribute to appear only in the No Change (*status quo*) option. In addition, assuming that respondents perceive attributes as independent, in the case of combinations of high-price low quality, it is regarded that they form rational expectations and hence these choice sets were not excluded from the questionnaires.

Another related element that could be included in the design and needed to be decided upon in advance was the possibility to measure interactions. Interactions offer the possibility to examine if the utility of each case varies, apart from the main attributes, with the value that any other attribute takes. This is particularly important for the second set of choice cards that include the Which River(s) are Improved attribute. In the context of this set of cards, what is interesting to explore is interactions between the levels of this location attribute and the environmental river attributes. Specifically, the interaction of this variable with the 'improvement' variables enables one to test whether people hold different values for each river regarding the subsequent improvements.

Furthermore, on the basis of prior knowledge it is regarded that interactions are present and it is intended to avoid causing bias on the main effects by not considering them. Other types of interaction could also be present in the case of environmental and socio-economic attributes or between the environmental attributes. For example, it could be argued that recreational activities are more important only when water appearance is improved. From this perspective those two attributes are partial substitutes for each other. However, it should be remembered that a drawback of testing for interactions is that the designs are larger, as they require more cases, meaning that the size of the questionnaire increases and it requires a bigger sample. The design used in this study accommodates the issue of interactions by using four blocks/versions for each sampled catchment.

Other model specification related decisions are whether nonlinear effects are to be taken into account or if extra variables such as socio-economic characteristics are to be added to the utility function. In this study, nonlinear effects were explored in all attributes except the attribute River Banks condition, while socio-economic variables were considered by interacting them with the constant term. It should be noted that nonlinearities in the river attributes do not come as a surprise. Furthermore, in general it is regarded that a wide range of levels has a broader application area and that it will produce parameter estimates with a smaller standard error.

After model specification considerations, the experimental design was generated. The chosen experimental design was a fractional factorial. Although the most well known fractional factorial design is the orthogonal the preference was for an efficient with four versions/blocks of choice cards. A different design was also created for each HA. The choice of a Bayesian efficient design was based on the growing belief that the property of orthogonality although it is desired in determining independent effects in linear models, is not compatible with the properties of non-linear discrete choice econometric models that are currently used (Train 2003). Furthermore, a Bayesian design considers priors as random parameters, hence making it more robust in mis-specifying them. Bliemer and Rose (2006) have argued that an efficient design implicitly minimises the correlations of a design, while it is related to diminishing decreasing asymptotic standard error when the sample size increases. As a result, it is not necessary to spend a lot of money in order to acquire a big sample when one can rather achieve low standard errors by determining a design with a higher efficiency. Considering the research design of two samples, the available budget, the interdependent nature of the good under valuation and the impact of greater complexity in survey questions of stated choice tasks, it seemed that adopting an efficient design was the optimal path.

The decision to make use of two different designs for each river catchment was dictated by the belief that the two targeted populations did not necessarily hold the same values for the attributes considered and therefore the priors could be different. As a result, the approach to use two samples and two designs was adopted.

In both discrete CEs, as shown in the previous figures (Figures 4.5, 4.6) three alternatives/options appeared in each choice card, two showing river improvements and a No Change or *status-quo* alternative that was constant across all choice sets. Each choice card, in the first set of four choice cards, consisted of four environmental river related attributes and an annual Cost attribute while the following four choice cards consisted of the same number of river attributes plus the location and the annual Cost attributes. The river attributes were all measured using three levels apart from River Banks and the annual Cost attribute. The same attributes and levels were employed in both designs.

Considering the complexity of the issue and the fact that people and especially non-users are not familiar with subjects such as river's ecological status, a decision has to be made about the number of choice tasks that each respondent will be presented with. A total number of eight choice tasks per respondent were selected, four and four for each set. Related to the choice of the number of choice sets for each respondent is the fact that the number of choice situations in the experimental design must be equal to or greater than the degrees of freedom. The four versions of four choice cards for each choice frame local river and both rivers, allowing degrees of freedom that are regarded sufficient for testing the thesis' hypotheses.

As Hensher *et al.* (2005, p.118) emphasised, "to determine the minimum number of treatment combinations necessary for a fractional factorial, the analyst is obliged to establish how many degrees of freedom are required for estimation purposes. This determination is dependent upon the number of parameters to be estimated at the time of modelling which in turn is dependent on how the analyst is likely to specify the model". In that sense specification of the model affects coding which affects degrees of freedom and "more degrees of freedom mean larger designs" (Hensher *et al.*, 2005, p.122). Furthermore, following Bateman *et al.* (2002), when the design is difficult to manage the options are to reduce the number of attributes and/or the number of levels offered, group the attributes into subsets or 'block' large designs.

Since a subset of all possible combinations is needed in order to construct the choice sets, some criteria for optimality or efficiency have to be followed. Particularly, that efficiency relates to measures of 'design goodness' (Kuhfeld *et al.*, 1994). Bliemer and Rose (2006) explained that the efficiency of a design could be derived from the Asymptotic Variance-Covariance (AVC) matrix that contributes to calculate an efficiency value typically expressed as an efficiency 'error'. The objective is to minimise this efficiency error. The most widely used measure, which was adopted in this thesis, is called the D-error, which takes the determinant of the AVC matrix Ω_1. A design with a sufficiently low D-error is called a D-efficient design. Depending on the available information on the prior parameters, there are different types of D-error. The one employed in this thesis is based on information derived by priors, assuming they are correct, and it is formulated as:

$$D_p\text{-error} = \det(\Omega_1(X, \tilde{\beta}))^{1/H}$$

Where D-error is a function of the experimental design X and the prior values $\tilde{\beta}$. H is the number of parameters to be estimated and power 1/H is used to normalise the D-error so as to be independent of the size of the problem. Other in-efficiency measures are also available like the A-error that takes the trace of the AVC. The one with the lowest A-error is called A-optimal. Although, several other efficiency criteria have been suggested as mentioned, the D- error is used in most research and should be preferred over the A-error which may have scaling problems (Bliemer and Rose, 2006).

Overall, efficient designs can be seen as designs that try to maximize the information from each choice situation by being statistically as efficient as possible in terms of predicted standard errors of the parameter estimates (Bliemer and Rose, 2006). However, an efficient design requires knowledge of the parameters' values (Batsell and Louviere, 1991) that are unknown at the time the design is constructed. As Bliemer and Rose (2006) point out, efficient designs will be able to outperform orthogonal designs, in case any information about the parameters is available. Therefore, a prerequisite is that prior parameters estimates need to be available. In this thesis, prior estimates were initially taken from the literature and then were updated from the pilot surveys that took place in each HA before the main survey administration. The efficient designs based on these priors were created and distributed to 90% of the respondents.

Other ways to acquire information about the priors is to use reasoning to determine at least the signs of the parameters, to use expert judgement, to find similar studies in the literature that could provide similar parameters and to run focus groups. This approach was followed before the pilot surveys took place in order to produce the choice cards for the pilot itself. As noted, although it seems that the design is heavily depended on the chosen prior parameters it can be tested for robustness in case one or more prior value is not correct. Alternatively, a Bayesian sequential efficient design can be adopted. However, due to time and budget constraints the latter was not an option for this project. The designs were generated in Microsoft Excel following an iterative optimization technique until no further improvements could be found and can be regarded as the most D-efficient designs conditional on the inclusion of the relevant restrictions. The design with the lowest D-error (0.304 for the Suir and 0.264 for the Boyne) was stored within the program.

Finally, reference should be made to Street *et al.* (2005) orthogonal D_z-optimal designs. The authors argued that these designs allow independent estimation of all effects, minimize the number of choice sets to estimate the effects of interest and are generally superior to most designs in the published literature. However, as Bliemer and Rose (2006) noted their disadvantages are that they are limited to the MNL model, are only optimal in cases where all parameters are equal to zero and in the case of alternative-specific parameters there is no simple principle that will lead to a D_z-optimal design. Finally, a third competing method is that of Choice Percentage designs that allocate attribute levels to the design to produce particular choice probabilities for each of the choice situations of the design (Rose and Bliemer, 2007).

4.6 Target population, survey mode, sampling strategy

As previously mentioned, surveys were conducted in two HAs - that of the Boyne and the Suir - which belong to two different RBDs. In order to test the thesis' hypotheses two versions of the questionnaire were developed, one for each HA and two samples in total were drawn, one for each HA. As such, two geographically different populations were targeted. The prime criterion for defining the target population of the study was to consider those who were going to receive the benefits of improvements. The considered population of those who would benefit included both users and non-users. Clearly at this point, it should be stressed that although the focus is on the local population that does not mean that all the user population has been included. A holistic sample should have included users of the river who are not local residents and visitors to the area, which is open to recreation. However, due to the available financial resources and time constraints the survey was limited to local residents. Households were selected instead of individuals as it is regarded that budgetary consumption decisions are taken at household level and in addition, the cost for water services is paid at the household level.

The selected survey mode was that of face-to-face interviews where respondents were asked questions by an interviewer in their home, following paper-and-pencil procedures. Bateman *et al.* (2002) summarizes the advantages of face–to–face interviews in that they offer the possibility to ask complex questions, like in CE, use complex questionnaire structures, collect a larger quantity of data and make extensive use of visual and demonstration aids.

The next step of the sample design was to draw a sample that would produce results unbiased and representative of the population and would be large enough to produce precise estimates. Hence, large variance and small bias was desired. As has been emphasized, "[h]ow well a sample represents a population depends on the sample frame, the sample size, and the specific design of selection procedures. If probability sampling procedures are used, the precision of sample estimates can be calculated" (Fowler 2002, p.10). As far as the sample frame population is concerned, the starting point was the target population of the HA of each river and within that an explicit list of registered voters. A prime concern was to achieve a representative territorial spread and minimize the coverage error or sampling frame bias using Groves' (1989) terminology. As is also stated, "most good survey designs are multi-stage designs with initial stratification, some type of clustering, and then some type of respondent selection procedure" (Bateman *et al.*, 2002, p.99). In this thesis, a stratified random sampling technique was employed and more specifically a multi-staged quota controlled probability sampling procedure, with randomly selected starting points.

Regarding the fact that postal codes are not available in HAs, the primary sampling units to consider were Electoral Divisions (EDs) within each catchment belonging to both urban and rural geographical locations. Hence, in order to achieve a firm, representative spread of the sample, the sample for each region was stratified by the electoral wards. Within each of the stratified cells (*i.e.*, electoral wards), the required number of sampling points was drawn using probability sampling procedures. In order to identify the number of sampling points, the number of interviews an interviewer could complete in a day *i.e.* the cluster size, was firstly derived. Then, using cumulative population figures, and utilizing the 'random start number and skip distance' method, 36 sampling points in each region were identified. It should be remembered that the selection of a particular sample from the frame, depending on how it is done, could incur sampling error and/or non-response error.

The second stage of the sampling procedure was the systematic sampling of individuals within each of the pre-selected EDs. At each point, the interviewer adhered to a quota control matrix based upon the known profile of all Irish adults in each area in terms of age and gender. The quotas for age and gender were based upon the Central Statistics Office (Ireland) Small Area Population Statistics from the 2006 Census. Socio-economic status was allowed to fall out naturally. Finally, within each sampling point the nucleus of each cluster of interviews was an address selected on a probability basis from the GEO Directory (an Irish Address Database). The GEO Directory was purely used to determine an interviewer's starting point. From each starting address sampled, interviewers followed the random route procedure (first left, next right, *etc.*) calling at every fifth residence (or every quarter of a mile in rural areas) to complete an interview, until their quota controls were fulfilled. The four blocks of the design for each river where evenly distributed within the two catchment areas. The total sample size was 504 respondents, 252 for each area, while each of the four versions was allocated to 63 respondents, which is considered sufficient for estimation results.

Experienced interviewers and tight supervision of the survey by the employed market research company produced a good quality of data. The following table (Table 4.6) summarizes the quota control matrix based upon the known profile of Irish adults in each HA in terms of age, gender and socio-economic status.

Table 4.6: Quota control matrix

		Socio-economic group								
Boyne		A	B	C1	C2	D	E	F1	F2	**Total**
Male	15-17	0	1	0	2	2	0	0	0	**5**
	18-24	0	4	6	8	1	0	0	0	**19**
	25-34	0	2	7	10	7	0	0	1	**27**
	35-54	1	5	10	23	6	0	5	1	**51**
	55-64	0	4	6	2	3	0	1	0	**16**
	65+	0	1	3	2	2	1	3	0	**12**
	Total	**1**	**17**	**32**	**47**	**21**	**1**	**9**	**2**	**130**
Female	15-17	0	0	1	2	2	0	1	1	**7**
	18-24	0	0	5	5	3	0	1	0	**14**
	25-34	1	0	14	7	3	0	0	0	**25**
	35-54	4	1	18	11	5	0	5	2	**46**

	55-64	0	1	4	6	6	0	1	0	**18**
	65+	2	2	2	0	3	0	2	1	**12**
	Total	**7**	**4**	**44**	**31**	**22**	**0**	**10**	**4**	**122**
Total	15-17	0	1	1	4	4	0	1	1	**12**
	18-24	0	4	11	13	4	0	1	0	**33**
	25-34	1	2	21	17	10	0	0	1	**52**
	35-54	5	6	28	34	11	0	10	3	**97**
	55-64	0	5	10	8	9	0	2	0	**34**
	65+	2	3	5	2	5	1	5	1	**24**
	Total	**8**	**21**	**76**	**78**	**43**	**1**	**19**	**6**	**252**
Suir										
Male	15-17	0	0	2	0	0	0	0	0	**2**
	18-24	0	1	9	3	2	2	2	0	**19**
	25-34	0	2	4	6	4	4	1	0	**21**
	35-54	0	4	11	8	5	3	7	0	**38**
	55-64	1	1	9	5	2	2	8	1	**29**
	65+	0	0	1	3	7	5	3	0	**19**
	Total	**1**	**8**	**36**	**25**	**20**	**16**	**21**	**1**	**128**
Female	15-17	0	0	0	0	0	0	0	0	**0**
	18-24	0	1	10	2	6	1	2	0	**22**
	25-34	0	1	9	4	9	0	1	0	**24**
	35-54	2	3	17	9	6	3	2	0	**42**
	55-64	0	1	4	1	3	3	4	1	**17**
	65+	0	2	2	3	4	4	3	1	**19**
	Total	**2**	**8**	**42**	**19**	**28**	**11**	**12**	**2**	**124**
Total	15-17	0	0	2	0	0	0	0	0	**2**
	18-24	0	2	19	5	8	3	4	0	**41**
	25-34	0	3	13	10	13	4	2	0	**45**
	35-54	2	7	28	17	11	6	9	0	**80**
	55-64	1	2	13	6	5	5	12	2	**46**
	65+	0	2	3	6	11	9	6	1	**38**
	Total	**3**	**16**	**78**	**44**	**48**	**27**	**33**	**3**	**252**

4.7 Chapter summary

The main part of this chapter reviewed the stages in the development of the questionnaire and design of the survey instrument. However, before that the case study rivers were presented along with the primary criteria that were considered for their selection. Specifically, rivers should be at risk, not very different in water and environmental quality conditions and pressures and not substitutes in consumption.

Then the main design stages of a CE were described. Namely, the selection of attributes, the assignment of levels, the choice of experimental design and the construction of choice sets that are required in order to proceed to the measurement of preferences. This chapter aimed to present how these issues were tackled in this empirical study.

According to the WFD, progress towards GES is monitored by a combination of biological and chemical means. As a result, one of the non-market benefits that were considered from the beginning was the provision of improved ecosystems. The second benefit referred to improved conditions for recreation in or around the water. This includes informal recreation like walking on the riverbanks and improved conditions for anglers. Finally, another pre-focus group 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 group of attributes.

This choice of benefits to be valued included a mixture of direct use values like recreation and non-use values such as biodiversity (option value). This choice of attributes is in line with expert and public expectations and offers the possibility to explore respondents' preference for both types of values and both rivers in order to understand what matters more for the public regarding current water policy.

An important part of this chapter also focused on the employed questionnaire. In this section, the research strategy of including two sets of choice cards within the same questionnaire was presented and the different sections of the questionnaire were described.

Issues concerning the choice of experimental design were then discussed. The decision for an efficient design was justified in light of recent research that favours its use because of the desirable characteristics it possesses. Of particular interest was the advantage that this design offers in terms of small sample size and statistical precision. The chapter closed with a reference to other important decisions that concerned survey design and that have an impact on the final output quality such as the target population, sampling strategy and survey mode selection.

5

PROFILE OF RESPONDENTS BY CATCHMENT AND PROTESTERS' ANALYSIS

5.1 Introduction

The objective of this chapter is to provide an overview of the main characteristics of each sample before the parametric analysis of choice that follows in Chapter 6. In addition, the chapter highlights decisions that needed to be taken at an early stage that had an impact on the way the data were subsequently analysed. Section 5.2 begins by presenting general results by catchment area. In particular, the focus is firstly on the examination of the profile of survey respondents. Experienced interviewers from TNS Ipsos/MRBI administered the survey in September/October 2009 to representative samples of 252 respondents drawn from the Irish adult population of each HA.

In analysing the data it became apparent from the beginning that a distinction was necessary between respondents who hold a 'genuine'/true zero value for the good in question and those who select the No Change option in order to protest against some aspect of the hypothetical market. The decision rules that allowed this classification are presented in Section 5.2.2. After revealing the profile of true zero bidders and protesters, the reaction of participants to the use of different sets of choice cards within the same survey is explored and results are reported in Subsection 5.2.2.1. After Sections 5.2.2 and 5.2.2.1, which reveal interesting conclusions on how to handle the data, socio-economic and other characteristics of respondents are presented in Sections 5.2.3 and 5.2.4. Before an initial analysis of choice is attempted and due to the considerable number of protesters in the survey special emphasis is given in Section 5.3 on explaining why respondents protested by modelling parametrically drivers for protesters. Finally, a summary of the main findings of the chapter is provided in Section 5.4.

5.2 General results by catchment area

5.2.1 Breakdown of samples according to HAs

The public survey was administered by experienced interviewers from TNS Ipsos/MRBI. A representative sample of 252 respondents in each catchment area was drawn in September/October 2009. Accounting for respondents refusing to complete the interview, the overall non-response rate for both catchments was about 39.5% (43% for the Boyne and 36% for the Suir). Employing a two sample test of proportions, it is interesting to note that the difference in non-response rates between catchments is statistically significant at 5% level ($z = 2.0628$, $Pr(|Z| < |z|) = 0.0391$, $Pr(Z > z) = 0.0196$). The effort to record the demographic characteristics of non-participants in order to account for non-response error did not produce enough detailed data (mainly gender recorded) to provide any valuable information worth citing. Table 5.1 reports the breakdown of respondents in each HA, according to the quotas used for sampling; that is age and gender.

Table 5.1: Profile of the survey sample

	Survey sample respondents (%)			
	Boyne HA	Boyne HA population	Suir HA	Suir HA population
A: Upper middle class	8 (3%)	6%	3 (1%)	15%
B: Middle class	21 (8%)	11%	16 (6%)	7%
C1: Lower middle class	76 (30%)	17%	78 (31%)	13%
C2: Skilled working class	78 (31%)	16%	44 (18%)	13%
D: Other working class	43 (17%)	37%	48 (19%)	33%
E: Lowest levels	1	5%	27 (11%)	7%
F1: Large farms (50 acres and upwards)	19 (8%)	6%	33 (13%)	12%
F2: Small farms (under 50 acres)	6 (2%)	1%	3 (1%)	2%
15-17 years	12 (5%)	8%	2 (1%)	6%
18-24 years	33 (13%)	9%	41 (16%)	10%
25-34 years	52 (21%)	23%	45 (18%)	19%
35-54 years	97 (38%)	37%	80 (32%)	35%
55-64 years	34 (13%)	11%	46 (18%)	14%
65 years and over	24 (10%)	10%	38 (15%)	14%
Male	130 (52%)	51%	128 (51%)	51%
Female	122 (48%)	49%	124 (49%)	49%
Total	**252**	**100,551**	**252**	**81,981**

Comparing the breakdown of respondents against the equivalent population figures (Small Area Population Statistics, 2006 Census) indicated that the samples appeared to be representative of the catchments' adult population as far as age and gender are concerned. However, deviations with regard to some socio-economic groups are observed as socio-economic class was left to fall naturally. Overall, considering samples' differences it is noted that the Suir sample compared to the Boyne sample has more large farms, more households in the lowest levels of occupation and fewer households in the skilled working class. Table 5.2 reports the breakdown of respondents according to counties in each HA. Boyne HA includes more counties than that of the Suir while, in both cases there is a county which is more representative of the catchment and hence sampling reflects that. For the Boyne HA this catchment is Meath while for the Suir HA it is Tipperary.

Table 5.2: Profile of the survey sample according to geographical distribution (counties) within the HA

Survey sample respondents (%)			
Boyne HA		Suir HA	
Cavan	13 (5%)	Tipperary	210 (83%)
Kildare	13 (5%)	Waterford	28 (11%)
Westmeath	15 (6%)	Kilkenny	14 (6 %)
Louth	4 (2%)		
Meath	186 (74%)		
Offaly	21 (8%)		
Total	**252**		**252**

Before the chapter proceeds to present respondents' socio-economic characteristics, and attitudes in the case study rivers, the classification of protesters is an important issue which should first be dealt with.

5.2.2 Classification of protesters

Before the distribution of responses is presented in more detail, it is necessary to look closer at the profile of individuals and make a distinction between protesters who either object to valuing the environment for ethical reasons or object to the method of payment, and non-protesters who hold 'genuine' zero values (Hanley *et al.*, 2006a). In the context of this CE survey a protester is defined by s/he choosing No Change consistently in all choice cards, in contrast with the CVM survey where only one (most of the time) valuation question is included. As Hanley *et al.* (2006a) noted *status quo* response in CE studies may be analogous to a zero bid in CVM studies. It should be remembered that pilot testing of the survey instrument involved 48 respondents, 24 at each catchment. Of these respondents, about 29% in the Boyne catchment and 37% in the Suir catchment consistently chose the *status quo* option from which about half were protesters.

Table 5.3 offers an overview of respondents' reaction to the choice tasks. The third row of Table 5.3 refers to respondents who, although they chose the No Change option in the first four cards (local river), differentiated their choice in the second set of cards and *vice versa*. These respondents are classified in the following subsection 5.2.2.1.

Table 5.3: Profile of respondents according to their response to CE for both sets of choice cards

	Survey sample respondents (%)		
	Boyne HA	Suir HA	Both HAs
Option A/B	190 (75%)	67 (27%)	257 (51%)
No Change	55 (22%)	164 (65%)	219 (43%)
Differentiated choice	7 (3%)	21 (8%)	28 (6%)
Total	**252**	**252**	**504**

As demonstrated, a considerable proportion of respondents, especially in the case of the Suir HA, chose systematically the No Change option. Actually, the difference of proportions between the two samples is statistically significant at 1% level ($z = 9.7361$, $Pr(|Z| < |z|) = 0.000$).

Respondents who chose the No Change option consistently in both choice cards were asked to state the reason why, as well as respondents who gave a zero bid in the PC-CV question. This strategy was followed since the pilot study and focus group participants did not differentiate between the choice sets. Furthermore, an important consideration was to keep the questionnaire as simple as possible for both the interviewer and interviewee.

As a result, in the case of respondents who chose the No Change option consistently for both sets of choice cards it was more straightforward to distinguish between them by making use of the relevant follow-up question that asked respondents to choose the reasons for doing so. At this point, it should be noted that since this question allowed for multi-coding there have been cases where respondents chose along with true zero related reasons statements that coincided with protesters' behaviour. These were identified as protesters. For example, a respondent who states "I can't afford to pay" but also "The Government/other body should pay" and/or "Those who pollute the river(s) should pay" is identified as protester since although s/he is not able to pay, they take the opportunity to express an opinion about who should bear the cost and hence is protesting against some aspect of the hypothetical market. The answers that the relevant follow-up question are presented in Table 5.4 along with their frequencies.

Table 5.4: Profile of respondents according to their reasons for choosing the No Change in the CE (multi-coding)

	Boyne HA	Suir HA	Both HAs
1. I cannot afford to pay	28 (22%)	92 (32%)	120 (29%)
2. I object to paying taxes	12 (9%)	6 (2%)	18 (4%)
3. The improvements are not important to me	6 (5%)	4 (1%)	10 (2%)
4. The No Change option is satisfactory	7 (5%)	10 (3%)	17 (4%)
5. The Government/Council/other body should pay	16 (13%)	39 (14%)	55 (13%)
6. I don't believe the improvements will actually take place	14 (11%)	27 (9%)	41 (10%)
7. Those who pollute the river(s) should pay	16 (13%)	47 (16%)	63 (15%)
8. I don't use the river(s)	8 (6%)	30 (10%)	38 (9%)
9. I am not interested in improving rivers'	5 (4%)	1	6 (1%)

quality in general			
10. I need more information to make such a decision	3 (2%)	4 (1%)	7 (2%)
11. There was too much information and I was confused	-	9 (3%)	9 (2%)
12. I didn't understand the information in the questionnaire	-	-	-
13. I think the situation presented is too hypothetical	6 (5%)	8 (3%)	14 (3%)
14. I think the question is morally offensive	1	-	1
15. Don't know	5 (4%)	7 (2%)	12 (3%)
Total	**127**	**284**	**411**

Statements 1, 3, 4, 8 and 9 were identified as compatible with economic theory and hence as true zeros or 'genuine' zero bids since respondents indicated that they do not value the good in question or cannot afford to pay for it. On the other hand, protesters were those who chose not to pay although they may hold a value for the good in question. Their disapproval expressed as refusal to reveal the true value may be justified on the grounds of ethical reasons/lexicographic preferences (Spash and Hanley, 1995), distaste for the vehicle of payment, doubt over mismanagement and, in general, beliefs representative of attitudes towards the valuation method.

In addition, in the above table it could be argued that those who stated the need for more information to make such a decision and "Don't know" answers reflect preference uncertainty rather than protesting. Regarding statement 10, although it may reflect preference uncertainty it was always coupled with other statements of protesting and is classified accordingly. As far as the "Don't know" answers are concerned, they were not identified as protesters as the respondents may not see enough welfare increase in order to pay. However, as Meyerhoff *et al.* (2009, p.19) noted, "[t]here might be no clear-cut dividing line between respondents who protest and respondents who do not protest in a stated preference survey. Protesting may rather be gradual ranging from strong to weak protesting while influencing respondents' WTP". A recent discussion on this issue is offered in Brouwer and Martín-Ortega (2011).

Trying to explore the theoretical background of protest bidders and focusing on the CVM, Sugden (1999) stated three reasons that can explain the deviation of CVM answers from the underlying neo-classical model of choice. These reasons are random errors, flawed study design and a defective theoretical model either in terms of the fundamental premises or in terms of some of the supplementary assumptions. With regard to the latter, it is suggested that in order to explain individual behaviour in relation to public goods, researchers should take account of factors other than preferences.

Literature has demonstrated three ways to deal with protesters at least in a CVM context: "(1) drop them from the data set; (2) treat the protest bids as legitimate zero bids and include them in the data set; or (3) assign protest bidders mean WTP values based upon their socio-demographic characteristics relative to the rest of the sample group by using econometric techniques" (Halstead *et al.*, 1992, p.161). Another interesting note is that it is regarded that an untruthful reply to a valuation question due to some protest reason can be shared by all respondents irrespective of whether they are willing to pay or not (Meyerhoff and Liebe, 2008). In order to identify protest beliefs, Meyerhoff and Liebe (2008) used four statements aiming at different aspects of an individual contribution to the provision of a public good. However, all respondents, irrespective of their willingness to pay, answered the statements on a five-point scale. Findings showed evidence that a protest attitude, an attitude towards the good, and perceived choice task complexity influence the choice of the *status quo*. The authors also compared CVM and CE performance with respect to protest responses without finding any clear pattern of differences other than the fact that in one of the two study regions, the effect is weaker in CE than in CVM.

In order to group the protesters to examine them more closely they were assigned into four main categories following Buchli (2004). Table 5.5 summarizes these categories.

Table 5.5: Categories of non 'genuine' zero bids

1. Dissension regarding specific aspects of CE study
I object to paying taxes
There was too much information and I was confused
I didn't understand the information in the questionnaire
I think the situation presented is too hypothetical
2. Mistrust on institutional delivery of good
I don't believe the improvements will actually take place
3. Property rights related
Those who pollute the river(s) should pay
The Government/Council/other body should pay
Paying enough already
4. Holding 'moral' or 'ethical' views
I think the question is morally offensive

Following the previous classification the revealed profile of protesters presented in Table 5.6 shows that in both HAs the majority of protests are related to the 'property rights' category, while mistrust on institutional delivery of good seems to be of equal concern in both samples. In addition, more protesters in the Boyne sample show evidence of dissension regarding aspects of CE study than in the Suir.

Table 5.6: Profile of protesters by categories

	Boyne HA	Suir HA	Both HAs
1. Dissension regarding specific aspects of CE study	18 (28%)	23 (17%)	41 (20%)
2. Mistrust on institutional delivery of good	14 (22%)	27 (20%)	41 (20%)
3. Property rights related	32 (49%)	86 (63%)	118 (59%)
4. Holding 'moral' or 'ethical' views	1	-	1
Total	**65**	**136**	**201**

Focusing on true zeros after accounting for multi-coding it is evident from Table 5.7 that the majority justified their zero bids by revealing their inability to afford a payment, while the second most popular reason at least for the Suir sample was the fact that participants did not use the river.

Table 5.7: Profile of true zero bidders

	Boyne HA	Suir HA	Both HAs
I cannot afford to pay	12 (52%)	44 (49%)	56 (50%)
I don't use the river(s)	1 (4%)	21 (24%)	22 (20%)
The No Change option is satisfactory	2 (9%)	7 (8%)	9 (8%)
I am not interested in improving rivers' quality in general	-	-	-
The improvements are not important to me	2 (9%)	2 (2%)	4 (3%)
Combinations of the above	1 (4%)	8 (9%)	9 (8%)
Don't know	5 (22%)	7 (8%)	12 (11%)
Total	**23**	**89**	**112**

After the classification of the No Change responses, another distinction is made in the following subsection according to the first four choice cards that concern improvements only in the local river and the second four cards that involve the extra location attribute, Which River(s) are Improved?

5.2.2.1 Breakdown of respondents according to their response to the different sets of choice cards

In the previous subsection, Table 5.3 presented a profile of respondents according to their response to the CE question for all eight choice cards. Table 5.8 breaks down the No Change option to true and protest zeros following the classification of Section 5.2.2.

Table 5.8: Profile of respondents to the CE for both choice sets, after classification of zeros

	Survey sample respondents (%)		
	Boyne HA	Suir HA	Both HAs
Option A/B	190 (75%)	67 (27%)	257 (51%)
True zeros	21 (8%)	74 (29%)	95 (18%)
Protest zeros	34 (13%)	90 (36%)	124 (25%)
Differentiated choice	7 (3%)	21 (8%)	28 (6%)
Total	**252**	**252**	**504**

As shown in both tables (Table 5.3 and 5.8), there were respondents who differentiated between the groups of choice cards more in the Suir sample than in the Boyne sample (8% and 3% respectively). This difference of proportions is statistically significant at 5% level ($z = 2.4618$, $Pr(|Z| < |z|) = 0.013$) providing evidence of deviance on how respondents in each catchment reacted to the two frames of choice. It should be noted however, that different experimental designs were employed in each catchment area in order to account for the fact that priors may differ between the samples. The next table presents how differences in behaviour were distributed between the two groups of choice cards. Evidence from the table shows that the majority of respondents that differentiated their choice in the Suir sample preferred to pay for improvements within the context of their local river, while for the Boyne sample results were mixed.

Table 5.9: Profile of respondents discriminating between the two choice sets

	Survey sample respondents (%)		
	Boyne HA	Suir HA	Both HAs
Pay for improvements only in the first four choice cards	4 (57%)	17 (81%)	21 (75%)
Pay for improvements only in the second four choice cards	3 (43%)	4 (19%)	7 (25%)
Differentiated choice	**7**	**21**	**28**

However, as a follow-up question was not asked for those differentiating between the two choice sets, an attempt was made to distinguish their motivation taking information from other responses within the survey. Some remarks were that in any direction of reported differentiated choice, respondents give a positive amount for their local river in the CVM question showing that they do hold a value for the improvements to take place in their HA. As a result, responses to the CVM question serve as an extra check. Furthermore, it is not safe to assume that those who differentiate between the two groups of choice cards protest necessarily against the framing of the choice as both sets of cards differ in levels concerning the attributes so there is the possibility that they may find combinations of improvements not interesting or important. In order to distinguish between protesters and true zero bidders in the profile of respondents behaving differently between the two choice sets, each of the 28 respondents was further examined in more detail. The following decision rules were employed:

First, the focus is on those who consistently chose the No Change option in the first group of choice cards concerning the local river, while bidding positively in one of the choice cards from the second group (second row of Table 5.9). The majority of those respondents make only one positive choice out of four. The profile of these three respondents for the Boyne sample is that they are non-users and they either chose improvements that coincide with the Boyne or both rivers. In only one case, the chosen improvements associated with the Boyne were less than those the respondent could achieve at the same price in the first group of choice cards so this person seemed to behave inconsistently. This last case is excluded from the parametric analysis while the first two are included as true zeros.

In the case of the Suir sample, the four respondents are mainly users of the river and they make only one choice out of four cards in order to choose more improvements in the Suir compared to the first four cards apart from one person who decided not to choose an improvement in the Suir. However, that person believes that the Suir's quality is "satisfactory" and makes only one choice that involves the Boyne. These respondents are more likely to state true zeros concerning their response to the first four choice cards and are treated as such. Finally, one person showed inconsistent behaviour. In particular, that person made a choice that favoured her/his river *versus* both rivers although the improvements in the local river are at the same price and are not better than in the first four cards. That means that when this respondent is faced with the location variable s/he prefers improvements that had previously been rejected only because they related to her/his local river even though it would be possible to achieve more improvements in both rivers.

In the case of respondents that chose Option A/B in the first four choice cards and No Change in the second group of choice cards (first row of Table 5.9) their pattern of behaviour reveals the following. First, the majority of them once again make only one positive choice out of four cards. The protesters are those who although choosing a positive bid in the first four cards, then chose the zero amount on the second set of cards even if they have the chance to achieve more improvements in both rivers at the same or an even smaller price than the local river that has already chosen in the first four cards. According to this rule, four out of four in the Boyne sample and three out of twenty one in the Suir sample are protesting in the second group of cards. The rest are regarded as true zeros and the profile of respondents behaving differently between the two choice sets can be further broken down as shown in Table 5.10. Following analysis, it is possible to differentiate positive, zero and protest bids between the two sets of choice cards for each catchment. Results are reported in Table 5.11.

Table 5.10: Profile of respondents discriminating between the two choice sets, after classification of zeros

	Survey sample respondents		
	Boyne HA	Suir HA	Both HAs
True value (zero or positive)	2	17	19
Protest	4	3	7
Inconsistent	1	1	2
Differentiated choice	**7**	**21**	**28**

Table 5.11: Detailed profile of respondents according to different choice scenarios

	Boyne HA		Suir HA	
	Local river (1st four cards)	Both rivers (2nd four cards)	Local river (1st four cards)	Both rivers (2nd four cards)
Option A/B	194 (77%)	192 (76%)	84 (33%)	70 (28%)
True zeros	23 (9%)	21 (8%)	77 (31%)	88 (35%)
Protest zeros	34 (13%)	38 (15%)	90 (36%)	93 (37%)
Inconsistent	1	1	1	1
Total	**252**	**252**	**252**	**252**

A first observation is that the Boyne sample does not differentiate between the two sets of choice cards when it comes to paying for improvements. On the other hand, respondents in the Suir catchment seem to react differently between the two frames of choice. Another observation is that there are more and statistically significant protesters than true zero bidders apart from in the case of the Suir, where both rivers are to be considered. Lastly, the Suir sample compared to the Boyne sample gathers more zero responses in both sets of choice cards. Differences are statistically significant (at 1% level) for both true and protest bids.

As a result of the use of different sets of choice cards and of respondents' reactions, an initial thought was to proceed to the analysis of data by discriminating between the first four cards and the last four. However, as will be explained, the latter group of choice cards did not allow extensive analysis while differentiations within each sample were not very distinctive so as to justify this separation. Therefore, the descriptive statistics reported in the following section concern the first four cards since the analysis of the following chapters is based on them. In addition, responses are categorised as protesters, positive and true zeros. It is noted that the two inconsistent respondents are included in the group of protesters in the reported descriptive statistics but are excluded from the parametric analysis that follows.

5.2.3 Respondents' profile according to demographic, socio-economic, belief, knowledge, attitudes and behavioural characteristics

Regarding gender distribution, Tables 5.12 and 5.13 show that the male proportion was higher compared to the female as was the male contribution to positive bids for both samples. However, women seemed to protest more about paying for improvements at least in the Suir sample. In both samples, more respondents were between 35–54 years old while most of the protesters were over 35 years old. As shown in Tables 5.12 and 5.13, lower middle class and working class were the occupation categories that dominated in each catchment. A difference between the two catchments was observed in the E and F1 social class. As a result, the Suir seemed to have more respondents in the lowest levels compared to the Boyne, as well as larger farms. Table 5.12 also shows that the C1 and C2 classes gathered the most protesters while in the case of the Suir (Table 5.13), lower middle class and other working class demonstrated the most. In general, C1 class responses were distributed almost evenly between positive bids and protesters.

The educational profile as reported in Table 5.12 reveals that 71% of respondents in the Boyne sample had attained at least a secondary school-leaving certificate. The percentage for the Suir sample is 69%. It is also worth noting that in both samples the majority of protesters demonstrated an educational level which was at least lower than that of the secondary school-leaving certificate. Regarding respondents' employment status, 50% of individuals in the Boyne were full-time employed while the percentage for the Suir was 44%. 48% of protesters were full-time workers in the Boyne and 45% in the Suir.

Table 5.12: The Boyne's respondents profile according to demographic and socio-economic questions

	Survey sample respondents (%)			
	Whole sample	Positive bidders	Zero bidders	Protest bidders
Gender				
Male	130 (52%)	104 (53%)	10 (43%)	16 (46%)
Female	122 (48%)	90 (46%)	13 (57%)	19 (54%)
Age				
15-17 years	12 (5%)	8 (4%)	1 (4%)	3 (9%)
18-24 years	33 (13%)	27 (14%)	3 (13%)	3 (9%)
25-34 years	52 (21%)	41 (21%)	6 (26%)	5 (14%)
35-54 years	97 (38%)	76 (39%)	2 (9%)	19 (54%)
55-64 years	34 (13%)	24 (12%)	7 (30%)	3 (9%)
65 years and over	24 (9%)	18 (9%)	4 (17%)	2 (6%)
Occupation				
A: Upper middle class	8 (3%)	5 (3%)	2 (9%)	1 (3%)
B: Middle class	21 (8%)	18 (9%)	-	3 (9%)
C1: Lower middle class	76 (30%)	58 (30%)	7 (30%)	11 (31%)
C2: Skilled working class	78 (31%)	63 (32%)	4 (17%)	11 (31%)
D: Other working class	43 (17%)	33 (17%)	7 (30%)	3 (9%)
E: Lowest levels	1	1	-	-
F1: Large farms (50 acres and upwards)	19 (7%)	13 (7%)	3 (13%)	3 (9%)
F2: Small farms (under 50 acres)	6 (2%)	3 (1%)	-	3 (9%)
Educational status				
Primary school	18 (7%)	15 (8%)	2 (9%)	1 (3%)
Secondary school-inter junior certificate	52 (21%)	35 (18%)	9 (39%)	8 (23%)
Secondary school-leaving certificate	79 (31%)	63 (32%)	5 (22%)	11 (31%)
Post-leaving certificate course, *etc.*	29 (12%)	23 (12%)	2 (9%)	4 (11%)
National Cert/Diploma or Cadetship	26 (10%)	20 (10%)	2 (9%)	4 (11%)
Primary Degree	30 (12%)	22 (11%)	2 (9%)	6 (17%)
Postgraduate Diploma or Masters Degree	16 (6%)	14 (7%)	1 (4%)	1 (3%)
Doctorate	-	-	-	-

Refused	2 (1%)	2 (1%)	-	-
Employment Status				
Working full-time (occupation/paid job of 30+ hours per week)	126 (50%)	105 (54%)	4 (17%)	17 (48%)
Working part-time (occupation/paid job of 18-29 hours per week)	18 (7%)	12 (6%)	2 (9%)	4 (11%)
Working part-time (occupation/paid job of 17 or less hours per week)	3 (1%)	2 (1%)	-	1 (3%)
Student	25 (10%)	17 (9%)	3 (13%)	5 (14%)
Housewife	26 (10%)	15 (8%)	6 (26%)	5 (14%)
Retired	32 (13%)	26 (13%)	4 (17%)	2 (6%)
Unemployed	12 (5%)	10 (5%)	2 (9%)	-
Unable to work due to sickness or disability	2 (1%)	2 (1%)	-	-
Other	8 (3%)	5 (3%)	2 (9%)	1 (3%)
Number of household members aged 16 or younger				
One	55 (22%)	45 (23%)	3 (13%)	7 (20%)
Two	47 (19%)	38 (20%)	5 (22%)	4 (11%)
Three	18 (7%)	13 (7%)	1 (4%)	4 (11%)
Four	8 (3%)	6 (3%)	-	2 (6%)
Five	3 (1%)	2 (1%)	-	1 (3%)
Six	-	-	-	-
Seven or more	2 (1%)	2 (1%)	-	-
None	118 (47%)	87 (45%)	14 (61%)	17 (49%)
Refused	1	1	-	-
Years of residence				
Average years of residence in the area	22.55 (20.18)[a]	22.87 (20.05)	26.30 (23.91)	18.34 (18.23)
Location				
Average distance from respondent's townland to the closest tributary (km)	2.12 (3.67)[a]	2.17 (3.92)	2.19 (3.93)	1.76 (1.36)
Total	**252**	**194**	**23**	**35**

[a]Standard Deviation

About 50% of households in the Boyne sample had from one to three family members while the respective percentage in the Suir was 45%. In addition, about half of the protesters in both samples had no dependent. Another observation was that while the existence of dependents in the Boyne was associated mainly with positive responses rather than protests, in the Suir respondents were distributed across all three categories.

Another social parameter is related to the years of residence of the respondent in the area. In both catchments respondents resided in the area for more than 20 years. In the Boyne this may have been a reason for participants to reveal their true value for improvements in the river's environment while, in the case of the Suir no distinctive difference is observed.

The last characteristic reported in Tables 5.12 and 5.13 is distance in kilometre (km). Distance was calculated, as mentioned in Chapter 4, with the help of GIS by using townland information reported in the questionnaire and available geo-reference data of road and river distribution. With regard to this characteristic, households in the Suir catchment were located on average a little further from the closest tributary compared to those of the Boyne sample and they were also more spread out. Furthermore, in the Suir sample protesters were located further from the closest tributary than the positive bidders while in the Boyne the opposite was observed.

Table 5.13: The Suir's respondents profile according to demographic and socio-economic questions

	Survey sample respondents (%)			
	Whole sample	Positive bidders	Zero bidders	Protest bidders
Gender				
Male	128 (51%)	45 (54%)	38 (49%)	45 (49%)
Female	124 (49%)	39 (46%)	39 (51%)	46 (51%)
Age				
15-17 years	2 (1%)	1 (1%)	1 (1%)	-
18-24 years	41 (16%)	12 (14%)	22 (29%)	7 (8%)
25-34 years	45 (18%)	15 (18%)	13 (17%)	17 (19%)
35-54 years	80 (32%)	29 (35%)	16 (21%)	35 (38%)
55-64 years	46 (18%)	18 (21%)	14 (18%)	14 (15%)
65 years and over	38 (15%)	9 (11%)	11 (14%)	18 (20%)
Occupation				
A: Upper middle class	3 (1%)	2 (2%)	1 (1%)	-
B: Middle class	16 (6%)	6 (7%)	1 (1%)	9 (10%)
C1: Lower middle class	78 (31%)	32 (38%)	23 (30%)	23 (25%)
C2: Skilled working class	44 (17%)	17 (20%)	13 (17%)	14 (15%)

D: Other working class	48 (19%)	8 (10%)	18 (23%)	22 (24%)
E: Lowest levels	27 (11%)	5 (6%)	12 (16%)	10 (11%)
F1: Large farms (50 acres and upwards)	33 (13%)	13 (15%)	8 (10%)	12 (13%)
F2: Small farms (under 50 acres)	3 (1%)	1 (1%)	1 (1%)	1 (1%)
Educational status				
Primary school	34 (13%)	7 (8%)	14 (18%)	13 (14%)
Secondary school-inter junior certificate	44 (17%)	11 (13%)	15 (19%)	18 (20%)
Secondary school-leaving certificate	116 (46%)	40 (48%)	39 (51%)	37 (41%)
Post-leaving certificate course, *etc.*	13 (5%)	5 (6%)	2 (3%)	6 (7%)
National Cert/Diploma or Cadetship	15 (6%)	4 (5%)	3 (4%)	8 (9%)
Primary Degree	19 (8%)	12 (14%)	2 (3%)	5 (5%)
Postgraduate Diploma or Masters Degree	11 (4%)	5 (6%)	2 (3%)	4 (4%)
Doctorate	-	-	-	-
Refused	-	-	-	-
Employment Status				
Working full-time (occupation/paid job of 30+ hours per week)	111 (44%)	38 (45%)	32 (42%)	41 (45%)
Working part-time (occupation/paid job of 18-29 hours per week)	22 (9%)	10 (12%)	7 (9%)	5 (5%)
Working part-time (occupation/paid job of 17 or less hours per week)	1	1 (1%)	-	-
Student	17 (7%)	5 (6%)	9 (12%)	3 (3%)
Housewife	35 (14%)	11 (13%)	9 (12%)	15 (16%)
Retired	37 (15%)	9 (11%)	11 (14%)	17 (19%)
Unemployed	24 (10%)	8 (10%)	7 (9%)	9 (10%)
Unable to work due to sickness or disability	1	-	1 (1%)	-
Other	4 (2%)	2 (2%)	1 (1%)	1 (1%)
Number of household members aged 16 or younger				
One	43 (17%)	14 (17%)	17 (22%)	12 (13%)
Two	58 (23%)	25 (30%)	11 (14%)	22 (24%)
Three	13 (5%)	3 (4%)	5 (6%)	5 (5%)
Four	17 (7%)	7 (8%)	3 (4%)	7 (8%)
Five	2 (1%)	1 (1%)	-	1 (1%)
Six	-	-	-	-
Seven or more	-	-	-	-
None	118 (47%)	34 (40%)	41 (53%)	43 (47%)
Refused	1 (1%)	-	-	1 (1%)
Years of residence				
Average years of residence in the area	26.12 (18.54)[a]	27.19 (18.58)	23.33 (18.89)	27.49 (18.14)
Location				

Average distance from respondent's townland to the closest tributary (km)	3.25 (4.52)[a]	2.97 (4.56)	3.15 (4.20)	3.58 (4.75)
Total	**252**	**84**	**77**	**91**

[a]Standard Deviation

Finally, as the following table (Table 5.14) shows a sizeable proportion of respondents (85% for the Boyne and 82% for the Suir) refused to reveal their income. This high proportion made it difficult to approximate income based on the subsample of respondents who did provide their income. It is not uncommon in surveys of the general public for a sizeable proportion of respondents to refuse to provide their income. Instead of the missing income variable, the socio-economic class variable was used as a proxy for relative economic well-being.

Table 5.14: Profile of respondents according to annual income bands

	Survey sample respondents (%)		
	Boyne HA	Suir HA	Both HAs
Less than €6000	6 (2%)	4 (1%)	10 (2%)
€6000 to under €12000	5 (2%)	10 (4%)	15 (3%)
€12000 to under €18000	4 (1%)	18 (7%)	22 (4%)
€18000 to under €24000	4 (1%)	4 (1%)	8 (2%)
€24000 to under €36000	8 (3%)	5 (2%)	13 (3%)
€36000 to under €60000	8 (3%)	2	10 (2%)
€60000 or more	3 (1%)	1	4
Refused	214 (85%)	208 (82%)	422 (84%)
Total	**252**	**252**	**504**

A different group of questions attempted to explore the profile of respondents as far as their attitude towards the environment, their knowledge about the river systems or their belief on water policy was concerned. Table 5.15 shows that 45% of respondents think that the Boyne's general environmental quality is from "unsatisfactory" to "very unsatisfactory". Only 15% of the Suir sample shares the same view regarding their local river condition (Table 5.16). Not surprisingly in the case of the Boyne, most of these respondents are positive bidders while for the Suir responses are distributed across categories.

Table 5.15: The Boyne's respondents profile according to belief, knowledge, attitudes and behaviour related questions

	Survey sample respondents (%)			
	Whole sample	Positive bidders	Zero bidders	Protest bidders
Perceived environmental quality				
Very satisfactory	6 (2%)	3 (2%)	1 (4%)	2 (6%)
Satisfactory	58 (23%)	40 (21%)	4 (17%)	14 (40%)
Neither satisfactory nor unsatisfactory	24 (10%)	16 (8%)	4 (17%)	4 (11%)
Unsatisfactory	93 (37%)	87 (45%)	3 (13%)	3 (9%)
Very unsatisfactory	21 (8%)	17 (9%)	3 (13%)	1 (3%)
Don't know	50 (20%)	31 (16%)	8 (35%)	11 (31%)
Knowledge about the river *(multi-coding[a])*				
I have not ever heard about this river	-	-	-	-
I know that it exists, but I have not visited it	66 (26%)	42 (22%)	12 (52%)	12 (34%)
I know its historical or current uses	90 (36%)	70 (36%)	5 (22%)	15 (43%)
I visit/have visited the river	183 (73%)	150 (77%)	11 (48%)	22 (63%)
I am aware of its water quality problems	46 (18%)	36 (19%)	5 (22%)	5 (14%)
Use other river apart from local for recreational pursuits				
Yes	53 (21%)	40 (21%)	3 (13%)	10 (29%)
No	199 (79%)	154 (79%)	20 (87%)	25 (71%)
Knowledge of any specific water related policy taking place in Ireland				
Yes	41 (16%)	40 (21%)	-	1 (3%)
No	206 (82%)	151 (78%)	23	32 (91%)
N/S	5 (2%)	3 (2%)	-	2 (6%)
Being concerned about the environment				
Yes	198 (79%)	156 (80%)	16 (70%)	26 (74%)
No	45 (18%)	35 (18%)	4 (17%)	6 (17%)
Not sure	9 (4%)	3 (2%)	3 (13%)	3 (9%)
N/S	-	-	-	-
Total	**252**	**194**	**23**	**35**

[a]Total > 100% because of multiple answers

To investigate possible use values and familiarity with the rivers, respondents were questioned about their familiarity with the river in terms of knowledge, visitation, and awareness of its water problems. In the case of the Boyne (Table 5.15), a large proportion of respondents visited/had visited the river, while this proportion was half for the Suir sample. Therefore, in the latter the majority of protesters belonged to the category of those that knew about its existence but had never visited it. Clearly, the two samples demonstrate differences in terms of familiarity with their local river system.

Table 5.16: The Suir's respondents profile according to belief, knowledge, attitudes and behaviour related questions

	Survey sample respondents (%)			
	Whole sample	Positive bidders	Zero bidders	Protest bidders
Perceived environmental quality				
Very satisfactory	57 (23%)	20 (24%)	22 (29%)	15 (16%)
Satisfactory	67 (27%)	23 (27%)	19 (25%)	25 (27%)
Neither satisfactory nor unsatisfactory	22 (9%)	9 (11%)	5 (6%)	8 (9%)
Unsatisfactory	24 (10%)	10 (12%)	5 (6%)	9 (10%)
Very unsatisfactory	12 (5%)	4 (5%)	3 (4%)	5 (5%)
Don't know	64 (25%)	17 (20%)	20 (26%)	27 (30%)
N/S	6 (2%)	1 (1%)	3 (4%)	2 (2%)
Knowledge about the river *(multi-coding* [a]*)*				
I have not ever heard about this river	3 (1%)	-	3 (4%)	-
I know that it exists, but I have not visited it	138 (55%)	33 (39%)	57 (74%)	48 (53%)
I know its historical or current uses	57 (23%)	26 (31%)	4 (5%)	27 (30%)
I visit/have visited the river	99 (39%)	47 (56%)	17 (22%)	35 (39%)
I am aware of its water quality problems	26 (10%)	11 (13%)	2 (3%)	13 (14%)
N/S	3 (1%)	1	-	2 (2%)
Use other river apart from local for recreational pursuits				
Yes	10 (4%)	6 (7%)	1 (1%)	3 (3%)
No	242 (96%)	78 (93%)	76 (99%)	88 (97%)
Knowledge of any specific water related policy taking place in Ireland				
Yes	14 (6%)	9 (11%)	1 (1%)	4 (4%)
No	238 (94%)	75 (89%)	76 (99%)	87 (96%)
N/S	-	-	-	-

Being concerned about the environment				
Yes	234 (93%)	83 (99%)	65 (84%)	86 (94%)
No	7 (3%)	-	6 (8%)	1 (1%)
Not sure	9 (4%)	1 (1%)	5 (6%)	3 (3%)
N/S	2 (1%)	-	1 (1%)	1 (1%)
Total	**252**	**84**	**77**	**91**

[a]Total > 100% because of multiple answers

Another disparity between samples is also observed in terms of using non local rivers for recreational activities. Hence, 21% of the Boyne respondents stated "yes" against 4% of the Suir respondents. As a result, the Boyne respondents seemed to be more 'active', indicating also the existence of substitute rivers in the use-value represented by recreation. Finally, awareness of the Boyne sample concerning any water related policy was superior to awareness in the Suir sample (16% against 6%).

5.2.4 Respondents' profile according to psychometric characteristics, information process and rules that underlie choices

In this study an attempt was made to identify perceived cognitive ability related to the choice task in terms of common functions such as individual's ability to concentrate on the task, remember the necessary information, think clearly and logically and choose the best option. For each of these four statements the respondent was asked to indicate the degree of difficulty regarding the choice task on a 1 to 7 likert scale. For the analysis that follows, a total score of cognitive ability according to the reported degree of difficulty was calculated. Hence, the variable was treated as continuous. However, preceding the above question regarding self-perceived cognition performance, respondents were asked to state whether they found the last set of four cards more difficult than the first that concerned only the local river. If the answer was "yes", the above likert type of question concerned the last four cards that included the extra attribute Which River(s) are Improved. If the answer was "no" the question related to all eight cards.

It is worth noting that according to the following table (Table 5.17), residents of both catchments differentiated (significant at 1% level) between the two sets of cards in terms of difficulty. Therefore, for both samples the second set of cards with the extra attribute was seen as more demanding. However, differences in proportions between the catchments were not statistically significant. At this point, it should be made clear that since the two sets/groups of cards were not rotated there is a possibility that the cognitive burden was higher in the last four cards due also to fatigue compared to the first.

Table 5.17: Profile of respondents experiencing higher difficulty answering the second set of four cards

	Survey sample respondents (%)			
Boyne HA	Whole sample	Positive bidders	Zero bidders	Protest bidders
Yes	79 (31%)	57 (29%)	13 (57%)	9 (26%)
No	172 (68%)	137 (71%)	10 (43%)	25 (71%)
N/S	1	-	-	1 (3%)
Total	**252**	**194**	**23**	**35**
Suir HA				
Yes	65 (26%)	14 (17%)	26 (34%)	25 (27%)
No	186 (74%)	70 (83%)	50 (65%)	66 (73%)
N/S	1	-	1 (1%)	-
Total	**252**	**84**	**77**	**91**

In order to create one continuous variable that measures the overall degree of difficulty as defined in the likert scale question one more adjustment was needed. For those respondents that found the second set of cards more difficult and reported their scale of difficulty for only these cards, one unit was added to their stated scores. It should be noted that the decision to include these questions in the follow-up section instead of at the end of each set of choice cards was dictated by the desire not to tire the respondents with tasks other than the choice cards.

By adding up the score in each of the four statements for every respondent the resultant continuous variable shows that the smaller the score the higher the degree of difficulty. From Table 5.18 it is evident that respondents in the Boyne HA on average faced more difficulties (mean = 18.65) compared to the Suir (mean = 22.58) with the difference being statistically significant at 1% level. Finally, in the Suir sample protesters seemed to experience greater difficulty compared to non-protesters.

Table 5.18: Profile of respondents according to cognitive ability score

	Survey sample respondents (%)			
Boyne HA	Whole sample	Positive bidders	Zero bidders	Protest bidders
Mean	18.65	20.17	15.90	19.77
St.dev	6.80	5.50	7.73	7.11
Min-max	5-29	5-28	5-29	5-28
Total[a]	**245**	**192**	**22**	**31**
Suir HA				
Mean	22.58	24.33	21.60	21.77
St.dev	5.83	4.26	6.84	5.85
Min-max	6-28	12-28	6-28	9-28
Total[a]	**250**	**84**	**76**	**90**

[a] Due to N/S and "Don't know" answers

In order to investigate whether respondents understood important information about the valuation scenario and to explore decision rules and factors that affected their decision-making, respondents were asked to state if they agreed with each one of the statements presented in Tables 5.19 and 5.20 for the Boyne and the Suir respectively. This question was asked after the choice cards had been completed. As far as the Boyne sample is concerned, 58% of respondents thought that improvements were taking place in stretches of the river close to them instead of the whole catchment area. 68% of respondents fully considered their budget constraints while 60% wondered who else was paying for improvements. 64% mentioned the overall cost, 54% chose the most likely to happen option, 44% answered what family/friends would expect them to chose, 80% demonstrated a 'rational' behaviour and 44% answered by trusting their hunches.

Table 5.19: The Boyne's respondents profile according to psychometric questions

	Survey sample respondents (%)							
	Whole sample		Positive bidders		Zero bidders		Protest bidders	
	True	False	True	False	True	False	True	False
The payment concerned improvements in the stretches of the river(s) that are the closest to me	145 (58%)	107 (42%)	127 (65%)	67 (34%)	8 (35%)	15 (65%)	10 (29%)	25 (71%)
When deciding on the payment I fully considered what I would have to forgo in order to afford that payment	172 (68%)	80 (32%)	135 (70%)	59 (30%)	18 (78%)	5 (22%)	19 (54%)	16 (46%)
When deciding on the payment I was thinking who else was going to pay for the improvements	151 (60%)	101 (40%)	124 (64%)	70 (36%)	11 (48%)	12 (52%)	15 (43%)	20 (57%)
When deciding on the payment I was thinking of the overall cost of these improvements[a]	162 (64%)	89 (35%)	128 (66%)	65 (34%)	16 (70%)	7 (30%)	18 (51%)	17 (49%)
I chose the option most likely to happen as I think most of the people will choose that too	135 (54%)	117 (46%)	106 (55%)	88 (45%)	13 (57%)	10 (43%)	16 (46%)	19 (54%)
I chose the option thinking what my family and friends would expect/like me to choose	111 (44%)	141 (56%)	89 (46%)	105 (54%)	12 (52%)	11 (48%)	10 (29%)	25 (71%)

I chose the option that I thought was right given the improvements, the river(s) involved and my available income	202 (80%)	50 (20%)	166 (86%)	28 (14%)	17 (74%)	6 (26%)	19 (54%)	16 (46%)
I chose by only trusting my hunches	112 (44%)	140 (56%)	87 (45%)	107 (55%)	11 (48%)	12 (52%)	13 (37%)	22 (63%)
Total	**252**		**194**		**23**		**35**	

[a] 251 observations due to missing value

It is also worth noting that positive bidders and protesters reacted differently to the same statement. It seems that protesters compared to the positive bidders were more aware about the geographical distribution of improvements, were not as concerned about who else is paying, and what is the overall cost, although most of them trusted their hunches when choosing.

As far as the Suir sample is concerned (Table 5.20), compared to that of the Boyne, more people thought that improvements were going to happen in the closest distance from their home, were thinking who else is paying and were taking into account what the family/friends would think about their personal choices. Samples were also different in that fewer respondents in the Suir trusted their hunches when making a choice while, the profile of positive bidders and protesters also differed. For example, more protesters in the Suir answered true to all statements apart from the last one giving more evidence for the existence of a diversity of decision rules not only within but also between samples.

Table 5.20: The Suir's respondents profile according to psychometric questions

	Survey sample respondents (%)							
	Whole sample		Positive bidders		Zero bidders		Protest bidders	
	True	False	True	False	True	False	True	False
The payment concerned improvements in the stretches of the river(s) that are the closest to me	227 (90%)	25 (10%)	80 (95%)	4 (5%)	66 (86%)	11 (14%)	81 (89%)	10 (11%)
When deciding on the payment I fully considered what I would have to forgo in order to afford that payment	182 (72%)	70 (28%)	65 (77%)	19 (23%)	50 (65%)	27 (35%)	67 (74%)	24 (26%)
When deciding on the payment I was thinking who else was going to pay for the improvements	180 (71%)	72 (29%)	58 (69%)	26 (31%)	53 (69%)	24 (31%)	69 (76%)	22 (24%)
When deciding on the payment I was thinking of the overall cost of these improvements	164 (65%)	88 (35%)	55 (65%)	29 (35%)	52 (68%)	25 (32%)	57 (63%)	34 (37%)
I chose the option most likely to happen as I think most of the people will choose that too[a]	158 (63%)	93 (37%)	52 (62%)	32 (38%)	52 (68%)	25 (32%)	54 (59%)	36 (40%)
I chose the option thinking what my family and friends would expect/like me to choose[a]	144 (57%)	107 (42%)	54 (64%)	29 (35%)	43 (56%)	34 (44%)	47 (52%)	44 (48%)
I chose the option that I thought was right given the improvements, the river(s) involved and my available income	189 (75%)	63 (25%)	74 (88%)	10 (12%)	50 (65%)	27 (35%)	65 (71%)	26 (29%)
I chose by only trusting my hunches	47 (19%)	205 (81%)	10 (12%)	74 (88%)	56 (73%)	21 (27%)	16 (18%)	75 (82%)
Total	**252**		**84**		**77**		**91**	

[a] 251 observations due to missing value

Finally, Table 5.21 reports that on average the Boyne respondents took 26 minutes to complete the survey while in the Suir sample it took about 27 minutes. In addition, compared to the positive bidders the time the protesters needed in the Suir sample to complete the survey was slightly less.

Table 5.21: Profile of respondents according to time (minutes) spent for completing the survey

	Survey sample respondents (%)			
	Whole sample	Positive bidders	Zero bidders	Protest bidders
Boyne				
Mean	26.01	25.85	27.72	25.73
St.dev	8.91	8.75	9.09	9.93
Min-max	10-50	10-50	10-45	10-45
Total	**250**	**194**	**22**[a]	**34**[a]
Suir				
Mean	26.82	27.42	26.71	26.36
St.dev	6.35	6.56	6.28	6.24
Min-max	10-50	10-40	15-50	15-45
Total	**252**	**84**	**77**	**91**

[a]1 N/S

Summarising some of the findings of protesters' profile between the two catchments, it is noted that regarding the age in both samples more protesters were 35 years old and over, in the Suir sample from those working full time more were protesters while the opposite holds for the Boyne sample. Low middle and the skilled working class attracted most protesters in the Boyne, while in the Suir it was the skilled working class and other working class. The Suir sample gathered more protests of secondary or less than secondary education compared to the Boyne while females seemed to protest more in the Boyne than in the Suir. Other findings are that protesters in the Boyne reported a higher cognitive burden than in the Suir, while more protesters in the Boyne chose the option that they thought was right given the improvements, the river(s) involved and their available income compared to the Suir.

Regarding differences between protest and non-protest bidders it was observed that in the Boyne sample non-protesters resided longer in the area than protesters, perceived environmental quality not as satisfactory as protesters and made a choice considering more the improvements, the river(s) involved and their available income compared to protesters. In the case of the Suir sample, indicatively it is commented that non-protesters reported less difficulty with regard to cognitive burden than protesters, made a choice according to rational expectations and they were living closer to the river.

5.3 Aetiology of protest and non-protest bids in CE task

While a number of studies reveal protest values between 3 and 10%, a few report much higher rates. The Mourato *et al.* (2003) CE study on the Bathing Water Directive yielded protest responses equal to approximately 21% of the overall sample while similarly, a study done by Georgiou *et al.* (2000) identified 35% of the total sample as protests. Taking into account the considerable number of protesters in this study an attempt was made to explore the determinants of this behaviour. In addition, it is regarded that this analysis adds to the literature on CE since it is not an area that has been extensively investigated and just a few researchers have studied protest empirically (Meyerhoff and Liebe, 2008; Meyerhoff and Liebe, 2009; Barrio and Loureiro, 2010). Table 5.22 presents the variables by categories that were included in the MLE. Five categories were considered: socio-economic, belief, behavioural and knowledge, psychometric, location and design related. The analysis is focused on the set of the first four cards, as there was not much difference in the results compared to the second four. A dummy variable for the sampled catchment was also included.

Table 5.22: Variables included in analysis of protest bidders

Variable name	Description
Protesting (dependant variable)	1 if respondent is protesting, 0 otherwise
Socio-economic	
Age	Respondent's age scale 1 to 6, where 1=15 to 17 and 6=over 65
Working full-time	1 if respondent is full-time employed, 0 otherwise
Upper/middle class [a]	1 if chief income earner belongs to the upper middle or middle class, 0 otherwise
Low class	1 if chief income earner belongs to the low class, 0 otherwise
Farmer	1 if chief income earner is a farmer, 0 otherwise
Years of residence	Continuous variable in years of residence in the area
Belief	
"Unsatisfactory" river quality	1 if respondent finds river's general environmental quality "unsatisfactory", 0 otherwise
Psychometric	
"Who else is paying"	1 if when deciding on the payment respondent was thinking who else was going to pay for improvements, 0 otherwise
'Rationally'	1 if respondent chose the option that s/he thought was right given the improvements, the river(s) involved and her/his available income, 0 otherwise
Cognitive ability	Total score of cognitive ability, measured on a 1 to 7 likert scale, according to reported 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 (continuous variable)
Geographic	
Distance	1 if distance of respondent's townland is less than 2.5 km from closest tributary, 0 otherwise
"Improvements happen closest to me"	1 if respondent perceived that payment concerned improvements in the stretches of the river(s) that are the closest to him/her, 0 otherwise
River	1 if river is Boyne, 0 if Suir
Design	
Duration	Continuous variable reporting duration of responses to questionnaire in minutes

[a]Social classes were grouped as follows: upper middle class and middle class form the "Upper/middle class" category, lower middle class and skilled working class form the "Low middle class", other working class and those at lowest levels of subsistence form the "Low class" and large farmers + small farmers form the "Farmer" class.

Tables 5.23 and 5.24 provide the maximum likelihood estimates of the parameters of the fitted logit function. It is also noted that testing for collinearity and for different models of heteroskedasticity by using LR, Wald and Lagrange Multiplier Tests did not reveal any relevant evidence.

Table 5.23 reports results when the "don't know" answers to the screening follow–up question are categorised as protesters, while Table 5.24 reports results when they are considered as true zeros. One inconsistent respondent from each sample suspected of behaving strategically was also omitted from each sample. Although, the logit coefficients cannot be interpreted as the marginal effects on the probability of saying "yes", the signs of the coefficients are indicative of the direction of the marginal effects. The maximum likelihood coefficient estimates indicate how the probability of protesting is affected by the explanatory variables. As demonstrated by the signs, significant coefficients and goodness of fit measures, the logit model performs well in explaining variations in responses to the CE and in explaining protesters' behaviour. The different types of variables give an insight to factors that urge respondents to protest.

Table 5.23: Logit regression of protesters' responses ("don't know" classified as protesters)

	Boyne		Suir		Both	
Constant	-0.157	(-0.176)	2.293	(1.780)*	0.328	(0.566)
Socio-economic						
Age	0.293	(1.503)	0.314	(2.330) **	0.261	(2.609)***
Working full-time	0.110	(0.261)	0.634	(2.030)**	0.303	(1.324)
Upper/middle class	0.764	(1.178)	1.041	(1.801)*	0.581	(1.487)
Low class	-0.997	(-1.295)	0.710	(2.040)**	0.288	(1.028)
Farmer	1.343	(2.012)**	0.758	(1.661)*	0.711	(2.023)**
Years of residence	-0.033	(-2.322)**	-0.011	(-1.202)	-0.019	(-2.760)***
Belief						
"Unsatisfactory" river quality	-1.560	(-2.554)**	0.286	(0.606)	-0.561	(-1.924)*
Psychometric						
"Who else is	-0.738	(-1.666)*	0.962	(2.631)***	0.291	(1.137)

paying"						
'Rationally'	-1.257	(-2.738)***	-1.212	(-3.118) ***	-1.041	(-3.844)***
Cognitive ability	-0.0008	(-0.868)	-0.097	(-3.093)***	-0.001	(-2.309)**
Geographic						
Distance	-1.004	(-2.300)**	-0.664	(-1.998)**	-0.242	(-0.903)
"Improvements happen closest to me"	-0.990	(-2.113)**	-0.166	(-0.344)	-0.850	(-2.722)***
River					-1.780	(-5.867)***
Design						
Duration	0.003	(0.270)	-0.049	(-2.112)**	0.0005	(0.179)
LL	-80.303		-148.425		-254.595	
Restricted (Slopes=0) LL	-110.091		-173.531		-312.666	
% of correct predictions	88%		69%		74%	
McFadden Pseudo R^2	0.27		0.14		0.19	
Number of respondents	251		251		502	

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%.

More specifically, considering the Boyne sample of Table 5.23, being a farmer suggested a higher probability of protesting, while the opposite is observed for being a long time resident in the area, considering river's environmental quality "unsatisfactory", thinking "who else is paying", behaving 'rationally', living further away from the river and considering that improvements will take place in the respondent's proximity. For the Suir sample higher probability of protesting was associated with being older, full employed, belonging to the upper/middle class, low class and farmer compared to the low middle class and thinking "who else is paying". Taking longer to complete the survey, living further away from the river, facing less cognitive burden completing the task and behaving 'rationally' decreased the probability of protesting. Regarding the pooled model, the dummy variable for the catchment is significant in picking up differences in protest rates and showing that respondents from the Boyne HA were less likely to protest. Other variables that decreased also the probability of protesting in the pooled model are years of residence, finding river's environmental quality "unsatisfactory", experiencing higher cognitive burden, choosing 'rationally' and considering that improvements will take place in a household's proximity. Looking at the diagnostics (% of correct predictions and McFadden's R^2), the Boyne sample seemed to explain better protesters' behaviour compared to the Suir.

As the analysis of protest responses is likely to vary as a function of the way they are measured (Jorgensen *et al.*, 1999), Table 5.24 presents results when "don't know" responses are classified as true bidders. As a result, compared to Table 5.23 and regarding the Boyne sample, apart from the "who else is paying" variable which was no longer significant, no remarkable differences were noted. In the case of the Suir, differences were observed in the significance of social classes (only upper/middle class was significant), the years of residence variable which was now significant, and the survey length and cognitive ability related variables which were no longer significant. Furthermore, this classification seemed also to affect the goodness of fit of the model.

Table 5.24: Logit regression of protesters' responses ("don't know" classified as true bidders)

	Boyne		Suir		Both	
Constant	0.176	(0.193)	-0.751	(-0.802)	0.053	(0.091)
Socio-economic						
Age	0.150	(0.751)	0.369	(2.879)***	0.225	(2.242)**
Working full-time	0.196	(0.444)	0.474	(1.597)	0.308	(1.335)
Upper/middle class	0.564	(0.820)	0.936	(1.672)*	0.545	(1.387)
Low class	-1.269	(-1.437)	0.447	(1.336)	0.116	(0.409)
Farmer	1.265	(1.785)*	0.581	(1.328)	0.638	(1.795)*
Years of residence	-0.033	(-2.155)**	-0.017	(-1.957)*	-0.019	(-2.747)***
Belief						
"Unsatisfactory" river quality	-1.762	(-2.559)**	0.033	(0.073)	-0.685	(-2.263)**
Psychometric						
"Who else is paying"	-0.240	(-0.509)	1.102	(3.054)***	0.565	(2.133)**
'Rationally'	-1.294	(-2.711)***	-0.748	(-2.067)**	-0.855	(-3.119)***

Cognitive ability	-0.001	(-1.214)	-0.0008	(-0.570)	-0.001	(-2.031)**
Geographic						
Distance	-1.181	(-2.528)**	-0.568	(-1.785)*	-0.183	(-0.682)
"Improvements happen closest to me"	-0.917	(-1.829)*	-0.340	(-0.730)	-0.815	(-2.594)***
River					-1.771	(-5.760)***
Design						
Duration	0.002	(0.202)	-0.034	(-1.519)	0.0002	(0.081)
LL	-74.340		-157.237		-250.265	
Restricted (Slopes=0) LL	-101.391		-172.300		-302.655	
% of correct predictions	88%		65%		73%	
McFadden Pseudo R^2	0.27		0.09		0.17	
Number of respondents	251		251		502	

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%.

Other studies have also attempted to examine the factors that motivate protest bidders but in a CVM framework. For example, Musser *et al.*, (1990) used a logit model to examine determinants of protest zero bids in their study of farmland preservation in Pennsylvania and found that respondents with higher education levels, age, and income were less likely to register protest zero bids. In addition, beliefs by the respondent that development was "good," preservation of farmland was not necessary, and that it was important to preserve open space all decreased the probability of a protest zero bid.

Smith and Desvousges (1987) focused on the determinants of nonzero bids and employed a probit model in their study of risk-reducing behaviour regarding hazardous wastes in Acton, Massachusetts. Their results indicated that the probability of a zero bid, that included both true zero bidders and protesters, decreased with education and risk of exposure, and increased with greater knowledge of the issue. In the current study age increased the probability of protesting along with being a farmer, while beliefs like in Musser *et al.*, (1990) related for example to perceived environmental quality decreased the probability of a protest zero bid. Overall, it is concluded that factors such as familiarity with the good under question (indicated as well by the years of residence in the area), being located closer to the good (that may indicate use value or better knowledge of the issue) and believing that the current situation is not satisfactory are less likely to induce protesting behaviour. Furthermore, the same effect is observed for cognitive burden putting the emphasis on the importance of keeping the task of choice as easy as possible for the respondent.

Finally, in trying to explain the high number of protesters especially in the case of the Suir different speculations can be made. Overall, it could be argued that this is a reaction to the fact that households are not very familiar with water charges since at the time there was no such charge. Therefore, since water charges were abolished in the past but in light of the WFD are to be re-introduced, the rate of protesting may reflect the controversy surrounding this issue. Regarding the Suir sample that demonstrated a higher protesting rate, it could be the case (as focus groups also revealed) that being located further from Dublin it is less likely for decision makers to favour improvements in the Suir and that makes risk of mismanagement higher. Other reasons could also be hypothetical bias or perception of respondents' quality about their river which in the case of Suir was not considered to be particularly "unsatisfactory". Furthermore, in the Boyne HA about 33% of the river system is of bad quality compared to 23% in the Suir and differences between the sites may have also triggered protesting behaviour.

5.4 Summary of main findings

Reported in this chapter were primary the descriptive statistics that revealed respondents' profile and hence similarities and differences between samples. However, before the presentation of the statistics, Section 5.2 had as its main objective the classification of protesters. Results showed that a considerable proportion of participants, especially in the Suir sample, chose the No Change option. Further analysis of the data demonstrated that of these respondents, 36% in the Suir and 13% in the Boyne were protesting against the hypothetical scenario. Decision rules employed to distinguish between protesters and genuine zero bidders were explained. Very common reasons for protesting were related to property rights such as those who pollute the river should pay or the government should pay.

After the classification of participants' profile according to, for example, their socio-economic characteristics, environmental attitudes, awareness and other individual characteristics, descriptive statistics based on the first four cards of the survey was reported. The profile of participants was viewed in terms of positive bidders, true zeros and protesters. The decision to report descriptive statistics of only the first four cards was dictated by the fact that the analysis in the next chapters is mainly based on them since data from the second set of cards did not provide much insight. Nevertheless, the different approaches that were employed for their analysis are reported in Chapter 6.

Some of the differences between samples were observed with regard to occupation where the Suir sample had more farmers and more respondents in the low social class than the Boyne and the perceived environmental quality where more respondents in the

Boyne considered "unsatisfactory" the environmental quality of their river compared to the Suir. In addition, more respondents in the Boyne had higher than secondary education than in the Suir and had visited their local river. Other findings are that the Boyne residents lived closer to the river, were more informed about water policy, faced higher cognitive burden, reported less years of residence in the area and were thinking less about who else was going to pay for the improvements compared to the Suir residents.

The last section of the chapter focused on an important issue that arose from analysing the data and that is the non-negligible presence of protesters in both samples. Hence, a parametric analysis was followed in order to explore the determinants of this particular behaviour. Results showed that in the case of the Boyne, being a long time resident in the area, considering river's environmental quality "unsatisfactory", thinking who else is paying, behaving 'rationally', living further away from the river and considering that improvements will take place in the respondent's proximity rather than the whole catchment decreased the probability of protesting. For the Suir sample higher probability of protesting was associated with being older, full employed, belonging to the upper/middle class, low class and farmer compared to the low middle class and thinking who else is paying. On the other hand, taking longer to complete the survey, living further away from the river, facing less cognitive burden completing the task and behaving 'rationally' decreased the probability of protesting. Finally, the significant and negative variable for the catchment in the pooled model testified the differences in protest rates showing that respondents from the Boyne HA were less likely to protest.

6

ANALYSIS OF DISCRETE CHOICE MODELS

6.1 Introduction

This chapter presents the main results that derive from the application of the CE method to the adult population of the two catchment areas of the Boyne and the Suir, as well as the potential of BT use. The first two sections attempt to explore households' preferences for river improvements while the last two sections focus on the use of BT in order to assess its applicability in the context of this study.

Section 6.2 starts by presenting a number of discrete choice models in order to examine preferences. The models include the MNL, the NMNL and the mixed MNL models under two main specifications. The first specification includes only the river and Cost attributes along with *status quo* effects. The second is an extended version that incorporates aspects of individual heterogeneity by enriching the specification with respondents' various characteristics (socio-demographic, behavioural, psychometric and other variables). Then after the findings of different models are interpreted and the impact of different parameters on utility is discussed, an assessment regarding the best-fit model is offered and conclusions are drawn. The next section (Section 6.3) focuses on the Boyne catchment which provided a more robust sample with fewer weaknesses, in order to investigate in depth the existence of heterogeneity among respondents. HEV, error components models, MMNL with constrained distribution and LCM are also estimated in order to shed light on preferences formation.

Section 6.4 has as an objective the application of the BT method. It starts with a short overview of the different employed approaches to BT and refers to issues related to comparison of transfer estimates. Then the types of tests used in performing BT in this study are presented. Section 6.5 reports the results of BT and assesses method's applicability in terms of coefficients equality, implicit WTP estimates, and CS. Section 6.6 focuses on the second set of choice cards that were included in the survey and in particular, how derived data were treated in terms of analysis. Although, the survey was designed in order to measure how much households are WTP for river improvements in their local catchment area and in another catchment that also faces serious pressures, weaknesses of this group of choice cards did not allow their analysis and hypothesis testing. Finally, a summary of the main findings arising from both discrete choice models and BT is provided in Section 6.7.

6.2 Discrete choice models

A number of discrete choice model specifications are used to examine preferences for river improvements at both HAs. A complete list of the discrete choice models used in this chapter is reported in Table 6.1. The analysis follows the conventional random utility approach and starts with the workhorse of discrete choice model, the MNL. Then it proceeds progressively to the relaxation of this model's simplistic assumptions and moves towards models that enrich the analysis like NMNL and MMNL.

Table 6.1: Summary of discrete choice models

Boyne HA	Model	Description	Suir HA	Model	Description
Models 1	MNL	Basic	Model 2	MNL	Basic
Models 3	NMNL	Basic	Model 4	NMNL	Basic
Models 5	MMNL	Basic	Model 6	MMNL	Basic
Boyne HA			Suir HA		
Models 7	MNL	Extended	Model 8	MNL	Extended
Models 9	NMNL	Extended	Model 10	NMNL	Extended
Models 11	MMNL	Extended	Model 12	MMNL	Extended

Two different types of MNL models are estimated for each dataset, a basic and an extended. Model 1 is the basic choice model for the Boyne HA which explains respondents' choices between the environmental river alternatives solely as a function of their attributes and *status quo* effects. *Status quo* effects are represented by the No Change alternative and labeled as SQ. A positive sign indicates that *ceteris paribus,* the *status quo* alternative is more desirable while a negative sign would mean that it is less desirable than the other options. Model 2 is the corresponding model for the Suir sample.

MNL Models 7 and 8 capture observed heterogeneity, incorporating socio-economic, psychometric, attitudinal and other interaction regressors which are specific to individual respondents. Hence, differences between individuals are accounted for by interacting individual specific variables with the SQs. The resulting interaction coefficients show the effects that the individual-specific characteristics of the respondents have on the probability of choosing Option A or Option B with respect to the No Change alternative. Hence, a positive and significant coefficient means that respondents of a specific characteristic are more likely to choose the *status quo* than Option A or Option B. Models 7 and 8 are an extension of Models 1 and 2 including *status quo* effects and respondent heterogeneity. Using MNL as a baseline, different econometric models are estimated that do not rely on the IID assumption. The IIA property is relaxed at a first instance with the estimation of NMNL and MMNL models in Subsections 6.2.1 and 6.2.2 where two variants of each class of models are presented. Section 6.3 attempts a more in depth analysis based on the Boyne sample and including the HEV along with other models.

The NMNL model is employed to capture substitution patterns in a sense that respondents first choose between Change and No Change and then given that they have chosen Change, they select either the Option A or Option B alternative. This two-level nested structure can be justified by the fact that respondents may perceive Options A or B as substitutes compared to the No Change alternative which one may assume is more familiar to the respondents. For both variants of the NMNL models the IV parameter for the No Change branch has been normalised to 1 making it possible to inspect if the IV parameter for the Change branch was within the 0 – 1 range as random utility theory dictates. As presented in Chapter 3, IV parameters play an important role and their value is related to the inverse of the scale parameter capturing correlations among unobserved components of alternatives in the partition. As with the MNL, Model 3 and 4 specifications include, apart from the river attributes, an SQ dummy in order to capture *status quo* effects not captured by the NMNL specification. In Models 9 and 10 respondent heterogeneity is introduced along with the SQ that now captures *status quo* effects not captured by the individual-specific regressors and the NMNL model specification.

The last class of models considered in this chapter that offer more flexibility compared to the two previous are MMNL models. As noted in Chapter 3 on the methodology of CE, the main characteristics of these models are that they do not exhibit the IIA property and allow for random taste variation, unrestricted substitution patterns, and correlation in the unobserved factors. Again two different specifications are explored: A basic model including only the environmental parameters and the SQ and an extended model with the SQ and individual – specific regressors. For all MMNL models, the river attributes have been specified as random parameters and have been assumed to follow a normal distribution. All MMNL models were generated using 150 Halton draws.

For the assessment of the different models the following diagnostics are employed and reported for each of the models as presented in Chapter 3. Starting from the LL function at convergence, χ^2 statistic, pseudo- R^2 calculated as 1-(LL $_{\text{estimated model}}$/LL $_{\text{base model}}$), BIC statistic and percentage of cases correctly predicted are reported. The percentage of cases correctly predicted equals the number of correct predictions divided by the total number of observations. In addition, the LR-tests are used (i) to assess improvements in model specification and, (ii) to compare two different choice model specifications. In the first case, the statistic is -2 (LL $_{\text{base model}}$ – LL $_{\text{estimated model}}$) ~ χ^2 (degrees of freedom equal the number of new parameters in the estimated model) (Hensher *et al.*, 2005). If the -2 LL value exceeds the critical χ^2 value then the null hypothesis that the specified model is no better than the base comparison model is rejected. In the second case, the employed statistic is -2 ($LL_{largest} - LL_{smallest}$) ~ χ^2 (degrees of freedom equal the difference in the number of parameters estimated between the two models). Table 6.2 presents definitions of the variables used in the reported models.

6.2.1 Basic discrete choice models

Results from the basic models regarding improvements in the local rivers are reported in Table 6.4. These models included only river attributes and *status quo* effects in order to explain respondents' choices. Model 1 had a χ^2 statistic of 182.86. By comparing this value to the χ^2 statistic of 16.92 (with 9 degrees of freedom at $\alpha = 0.05$), the null hypothesis that the specified model was no better than the base comparison model was rejected and overall the model was statistically significant.

Examination of the coefficients revealed that in the Boyne sample they were all significantly different from zero, apart from the SQ, and of the expected sign. Although the SQ coefficient was found to be positive it was not significant. Coefficients of the river attributes also conformed to theoretical expectations of decreasing marginal utility apart from the case of the River Life attribute, while the coefficient for the Cost attribute was negative and significant. Furthermore, pseudo- R^2 was 0.10 and BIC statistic 802.58. Finally, the overall proportion of correct predictions equalled 0.48 showing that the basic model correctly predicted the actual choice outcome for 47% of the total number of cases. On the other hand in Model 2, the river attributes that were found to be statistically significant were River Life at both Good and Moderate levels and Appearance _A. The Cost coefficient in this model was also negative and significant. Not surprisingly the model revealed *status quo* effects since the SQ coefficient was positive and significant demonstrating respondents preference to the No Change alternative compared to Option A or Option B. Overall the model was statistically significant with a χ^2 statistic of 94.01, against a χ^2 critical value of 16.92 (with 9 degrees of freedom at $\alpha = 0.05$).

Table 6.2: Definition of variables included in discrete choice models

Variable name	Description
Choice card variables	
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 relative to No improvement
Appearance _S	Water Appearance: Some improvement relative to No improvement
Recreation _A	Recreational Activities: Walking, Boating, Fishing, Swimming (all recreational activities) relative to only Walking, Boating
Recreation _S	Recreational Activities: Walking, Boating, Fishing (some recreational activities) relative to only Walking, Boating
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	ASC $_{status\ quo}$ (No Change alternative)
Socio-economic	
Gender	1 if respondent is male, 0 if female
Age	Respondent's age scale 1 to 6, where 1=15 to 17 and 6=over 65
Hdegree	1 if respondent education is higher than secondary school, 0 otherwise
Depnt	Number of dependents in the household (8 categories from 'none' to 'seven or more')
Fullempl	1 if respondent is full-time employed, 0 otherwise
Middlecl	1 if chief income earner belongs to the upper middle or middle class, 0 otherwise
Knowledge/Attitudinal/Belief	
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
Psychometric	
Instinct	1 if respondent chose by only following her/his instinct, 0 otherwise
Socialcon	1 if respondent chose according to what family/friends would expect/like him/her to chose, 0 otherwise
Cognitive	Total score of cognitive ability, measured on a 1 to 7 likert scale, according to reported 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 (continuous variable)
Location	
Distance	Continuous variable of distance in km from respondent's townland to the closest tributary

As emphasised in Chapter 3, the assumption of IID error terms and its equivalent behavioural assumption of IIA underlies the MNL model. Hence, deviation from the IIA assumption would require the use of other more flexible models. The Hausman-McFadden test (1984) based on a comparison between the coefficient estimates obtained before and after the removal of one of the choice set alternatives is employed in order to test the null hypothesis of IIA that the differences in coefficients are not statistically significant. Table 6.3 shows the test statistics obtained from a process of alternate deletion of alternatives.

Table 6.3: Hausman test for IIA (basic models)

Boyne	Excluded Choice A	
	χ^2 (9 degrees of freedom) = 44.16	Pr(C>c) = 0.000
	χ^2 (9 degrees of freedom) = 91.86	Pr(C>c) = 0.000
Suir	Excluded Choice A	
	χ^2 (9 degrees of freedom) = 19.35	Pr(C>c) = 0.022
	Excluded Choice B	
	χ^2 (9 degrees of freedom) = 35.61	Pr(C>c) = 0.000

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 in that case of 16.92. Hence, acceptance of IIA was firmly rejected with the Hausman statistic being large and statistically significant well below the 5% level. This suggested that estimating the model as a MNL could generate misleading results.

As it is also evident from Table 6.3, it was not possible to estimate all of the restricted models as there was a possibility that restricting the choice set could lead to a singularity. Greene (2002) noted that it is possible when you drop one or more alternatives that some attribute will be constant among the remaining choices. Hence, it could be the case that there is a regressor which is constant across the choices and no variability; thus leading to singularities. In the case of the Boyne sample dropping the Option B alternative produced negative χ^2 values. In those cases the right conclusion is probably that they are zero (Greene 2002). The same result was observed dropping Option A and the No Change alternative in the Suir sample.

Employing the NMNL specification the aim was to explore if there existed sources of correlation between Option A and Option B alternatives suggesting that respondents first chose between Change and No Change. The NMNL models for each catchment are also reported in Table 6.4. The IV parameters for the Change branch were free to be estimated relative to the No Change branch IV parameter. In Model 3 regarding the Boyne HA all the parameters, except the SQ, were estimated with the expected sign and were all found to be statistically significant. Again, the River Life attribute did not conform to theoretical expectations of decreasing marginal utility of improvement.

Table 6.4: Boyne and Suir (basic models)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	MNL-Boyne	MNL-Suir	NMNL-Boyne	NMNL-Suir	MMNL-Boyne	MMNL-Suir
River Life _G	0.758 (3.915)***	0.472 (1.853)*	0.8378 (3.943)***	0.922 (2.477)**	0.906 (1.595)	0.531 (1.028)
River Life _M	0.982 (6.048)***	0.923 (3.728)***	1.101 (5.859)***	2.264 (4.444)***	2.184 (5.058)***	0.152 (0.229)
Appearance _A	0.982 (5.518)***	0.707 (2.958)***	1.019 (5.243)***	1.353 (3.723)***	2.939 (4.271)***	0.791 (1.077)
Appearance _S	0.658 (4.031)***	0.131 (0.565)	0.693 (3.943)***	1.042 (2.015)**	1.321(2.136)**	0.172 (0.279)
Recreation _A	0.397 (2.438)**	0.115 (0.536)	0.469 (2.623)***	-0.033 (-0.099)	1.583 (2.424)**	-0.444 (-0.663)
Recreation _S	0.265 (1.969)**	-0.188 (-0.919)	0.322 (2.209)**	0.241 (0.833)	0.635 (1.419)	0.039 (0.081)
River Banks	0.765 (6.427)***	-0.123 (-0.719)	0.824 (6.317)***	-0.699 (-2.215)**	2.358 (4.438)***	-2.629 (-3.185)***
Cost	-0.026 (-8.091)***	-0.027 (-6.868)**	-0.029 (-7.431)***	-0.050 (-5.933)***	-0.062 (-5.056)***	-0.098 (-5.803)***
SQ	0.292 (1.251)	1.324 (4.386)***	-0.130 (-0.399)	1.010 (5.807)***	-0.204 (-0.304)	0.672 (1.230)
IV par.-Change			0.731 (4.780)***	0.345 (3.448)***		
St. Deviations						
River Life _G					2.174 (2.577)**	0.911 (1.513)
River Life _M					1.502 (2.685)***	5.508 (5.072)***
Appearance _A					3.332 (4.839)***	3.578 (4.534)***
Appearance _S					4.173 (5.003)***	2.636 (3.498)***
Recreation _A					4.378 (4.982)***	3.267 (3.572)***
Recreation _S					3.076 (4.367)***	1.199 (2.320)**
River Banks					4.008 (5.599)***	3.810 (4.339)***
Diagnostics:						
LL	-778.38	-551.54	-777.10	-545.51	-673.28	-457.50
χ^2	182.86	94.01	668.01	146.92	560.61	499.99
Pseudo-R^2	0.105	0.078	0.30	0.118	0.293	0.353
BIC	802.58	574.41	803.99	570.92	716.31	498.15
Correctly predicted	47%	49%	47%	49%	47%	49%
Observations	868	644	868	644	868	644
# of respondents	217	161	217	161	217	161

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%.

Comparing the χ^2 statistic of 668.01 against the critical value of 18.31 (with 10 degrees of freedom at a = 0.05), overall the model was statistically significant. Inspection of the IV parameter for the Change option revealed that it was within the 0-1 range necessary to be consistent with random utility theory. Furthermore, it was significantly different from zero. However, in order to see if the parameter was statistically different from one a slight adjustment to the former test was made as referred in Hensher *et al.* (2005, p.548). Results from this test revealed that the IV parameter for the Change branch was not significantly different from one, meaning that the two branches should collapse to a single branch.

For Model 4, the pattern of results was similar to MNL Model 2 as far as the River Life, Appearance _A, Cost and the SQ attributes were concerned. Differences were observed in that Appearance _S was now significant as well as the River Banks attribute which however, was negative. The IV parameter was within the 0-1 range, significantly different from zero, but not from one, meaning that one branch should exist instead of two. It is worth noting as well that the significant SQ coefficient revealed that not all *status quo* effects were captured by the NMNL structure alone. Comparing the χ^2 statistic of 146.92 against the critical value showed that overall the model was significant. Furthermore, regarding the diagnostics BIC and % of choices correctly predicted, the NMNL models did not provide strong evidence of model improvement compared to MNL models.

Models 5 and 6 pertained to the estimation of MMNL for the Boyne and the Suir respectively. Parameter estimates in all models were generated using 150 Halton draws and river attributes were specified as random with normal distributions. In Model 5 regarding the estimated parameters the mean of all the random parameters apart from Recreation _S and River Life _G were statistically different to zero (at 1 and 5% significance levels) at the sample population level. The SQ, although negative remained insignificant. The Cost coefficient was statistically significant and of the expected sign. In addition, the statistically significant parameter estimates for derived standard deviations for all the random parameters suggested the existence of heterogeneity in the parameter estimates over the sampled population around the mean. This means that different individuals possess individual-specific parameter estimates that may be different from the sample population mean parameter estimate (Hensher *et al.*, 2005). Therefore, a single parameter estimate is insufficient to represent all sampled individuals. In addition, comparing the relative magnitude of the standard deviation parameters to the mean parameters, considerable variation in preferences across respondents was observed. Model 5 was statistically significant (χ^2 = -673.28 with 16 degrees of freedom and zero p-value) and had a pseudo – R^2 of 0.29. Other diagnostics are the BIC that equalled 498.15 and predicted correct cases that equalled 0.49.

Model 6 for the Suir (with 150 draws) revealed only negative and significant coefficients for Cost and River Banks and evidence of heterogeneity in parameters estimates of some attributes at 1% and 5% levels. In order to verify that these results were not due to the number of draws and to test if parameter stability was achieved at a different number of draws for each sample, the number of draws was increased to 1000. However, that model basically preserved the heterogeneity in the parameter estimates compared to Model 6 but did not indicate any considerable improvement and therefore is not reported. Comparison of diagnostics between the MNL and the MMNL models for both catchments indicated that the second group of models was superior to the initial MNL models.

Finally, reported results in Table 6.4 revealed an anomaly as far as the River Life attribute is concerned showing that the coefficient for the River Life _M attribute was higher than the coefficient for the River Life _G attribute. That could suggest that: (i) respondents were indifferent between the Good and Moderate levels and derived almost the same utility from this attribute regardless of level, (ii) preferences between the ecological conditions level Poor and Moderate and between Poor and Good were linearly related. Further insight is provided in Appendix E (Table E1) which presents the Wald tests of the reported basic models (Table 6.4) coefficient equality.

Observing the results of the Boyne sample, it was found that the null hypothesis of equal coefficients could not be rejected at the 95% confidence level for the River Life attribute and for the Recreation attribute at least for the MNL and NMNL models. In the case of the Suir sample, equality of coefficients could not be rejected for the Recreation attribute under all model specifications, for the Appearance attribute for the NMNL and MMNL models and for the River Life attribute for the MMNL and MNL models (at the 95% confidence level). These findings suggest that further work could consider (1) possibly recoding the variables that do not reject the H_0 of the Wald test using two levels (*e.g.*, Poor and High (Moderate/Good) for River Life attribute) and (2) using a single linear effect to capture the information observed using the non-linear effect previously specified in the dummy variables. However, in the analysis that follows the non-linear effect is pertained in order to explore further this issue.

6.2.2 Extended discrete choice models

Table 6.5 reports the results for the extended version of the discrete choice models of Subsection 6.2.1 in order to capture observed heterogeneity. Particularly, Models 7 and 8 incorporated socio-economic and other interaction regressors, which were specific to individual respondents. As these variables cannot enter directly into the model on their own, they have been interacted with the SQ. The final specification was reached based on a systematic process of eliminating variables found to be insignificant in previous specifications as well as *a priori* expectations based on theory and evidence from existing literature.

Model 7 was found to be statistically significant with a χ^2 of 387.96, against a χ^2 critical value of 33.92 (with 22 degrees of freedom at $\alpha = 0.05$). The same is true for Model 8 with a χ^2 of 270.56. As reflected by the increases in the LL function, pseudo-R^2, and the percentage of cases correctly predicted, compared to Models 1 and 2, Models 7 and 8 appeared to be superior. It is noticeable also that the BIC manifested this improvement after accounting for the loss of parsimony due to the increase in the number of parameters estimated.

Table 6.5: Boyne and Suir (extended models)

	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	MNL-Boyne	MNL-Suir	NMNL-Boyne	NMNL-Suir	MMNL-Boyne	MMNL-Suir
River Life _G	0.733 (3.649)***	0.477 (1.798)*	0.847 (3.763)***	0.846 (2.307)**	1.353 (3.165)***	-0.833 (-0.897)
River Life _M	0.955 (5.543)***	1.076 (4.115)***	1.115 (5.586)***	2.145 (4.229)***	1.761 (5.174)***	1.976 (1.920)*
Appearance _A	0.987 (5.217)***	0.857 (3.397)***	1.031 (4.845)***	1.381 (3.822)***	1.647 (3.845)***	2.329 (2.543)**
Appearance _S	0.650 (3.788)***	0.285 (1.135)	0.698 (3.682)***	1.044 (2.080)**	0.625 (1.591)	1.660 (1.758)*
Recreation _A	0.478 (2.797)***	0.179 (0.768)	0.570 (3.001)***	0.043 (0.129)	1.020 (2.151)**	1.908 (1.853)*
Recreation _S	0.287(2.040)**	-0.169 (-0.774)	0.360 (2.349)**	0.182 (0.630)	0.079 (0.245)	1.135 (1.911)*
River Banks	0.725 (5.804)***	-0.170 (-0.944)	0.801 (5.829)***	-0.654 (-2.100)**	1.249 (3.395)***	-1.207 (-1.845)*
Cost	-0.024 (-6.878)***	-0.030 (-7.075)***	-0.027 (-6.667)***	-0.048 (-5.699)***	-0.047 (-5.421)***	-0.149 (-3.707)***
SQ	1.521 (1.866)*	5.774 (6.976)***	0.994 (1.243)	5.261 (6.610)***	1.448 (0.940)	15.980 (2.634)***
GenderSQ	-0.599 (-2.461)**	-0.446 (-2.153)**	-0.581 (-2.431)**	-0.417 (-2.051)**	-1.146 (-2.154)**	-1.675 (-1.966)*
AgeSQ	0.084 (0.954)	-0.284 (-3.515)***	0.084 (0.904)	-0.274 (-3.454)***	0.182 (0.934)	-0.994 (-2.218)**
HdegreeSQ	0.399 (1.390)	-0.841 (-3.441)***	0.384 (1.379)	-0.801 (-3.179)***	0.982 (1.565)	-2.548 (-2.540)**
DepntSQ	-0.186 (-1.700)*	-0.348(-4.218)***	-0.196 (-1.821)*	-0.335 (-4.160)***	-0.204 (-0.975)	-1.322 (-2.372)**
FullemplSQ	-1.235 (-4.829)***	0.663 (3.034)***	-1.203 (-4.784)***	0.660 (3.074)***	-2.006 (-3.555)***	4.197 (2.386)**
MiddleclSQ	0.923(2.453)**	-1.923 (-4.133)***	0.904 (2.455)**	-1.893 (-4.162)***	1.778 (2.515)**	-6.930 (-2.413)**
DistanceSQ	0.105 (3.960)***	-0.044 (-1.819)*	0.105 (4.006)***	-0.046 (-1.923)*	0.218 (3.397)***	-0.128 (-1.316)
WaterpolicySQ	-2.392 (-3.739)***	-1.685 (-3.650)***	-2.410 (-3.783)***	-1.667 (-3.693)***	-2.639 (-2.651)***	-5.045 (-2.891)***
NsconsernedSQ	2.961 (5.352)***	1.366 (2.090)**	2.821 (5.203)***	1.267 (1.963)**	5.223 (3.766)***	14.921 (2.330)**
UnsatisfqualSQ	-1.071 (-3.772)***	-1.085 (-3.203)***	-1.089 (-3.871)***	-1.104 (-3.151)***	-1.623 (-2.854)***	-4.349 (-2.909)***
InstinctSQ	0.748 (2.930)***	1.138 (3.924)***	0.681 (2.716)***	1.116 (3.902)***	1.698 (3.024)***	5.316 (2.579)***
SocialconSQ	0.674 (2.887)***	-0.828 (-3.859)***	0.636 (2.773)***	-0.808 (-3.834)***	1.423 (2.422)**	-0.345 (-0.411)
CognitiveSQ	-0.060 (-2.651)**	-0.054 (-2.465)**	-0.071 (-3.105)***	-0.051 (-2.364)**	-0.135 (-2.772)***	-0.163 (-1.279)
IV par.-Change			0.554 (3.372)***	0.432 (3.486)***		
St. Deviations						
River Life _G					1.579 (2.335)**	5.661 (3.433)***

River Life _M					1.344 (2.924)***	7.738 (3.693)***
Appearance _A					1.098 (1.731)*	5.213 (2.745)***
Appearance _S					2.507 (5.168)***	1.782 (1.762)*
Recreation _A					1.749 (2.541)**	3.757 (2.970)***
Recreation _S					1.702 (3.201)***	0.566 (0.782)
River Banks					3.069 (5.822)***	4.410 (3.253)***
Diagnostics:						
LL	-678.69	-463.27	-675.83	-459.39	-616.65	-392.53
χ^2	387.96	270.56	798.47	296.98	612.36	603.56
Pseudo-R^2	0.219	0.226	0.371	0.244	0.331	0.434
BIC	737.50	518.95	737.32	517.60	694.18	465.93
Correctly predicted	51%	57%	51%	58%	50%	56%
Observations	840	632	840	632	840	632
# of respondents	210	158	210	158	210	158

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%.

In order to confront different specifications and assess the extent to which adding the interaction terms structurally changed the specifications, LR-tests were used. With a χ^2 of 199.38 against a χ^2 critical value of 22.36 (with 13 degrees of freedom at $\alpha = 0.05$ level) it was easily concluded that the extended model (Model 7) was superior to the basic model (Model 1). Hence, the hypothesis that the new model did not statistically improve the LL over the previous model with only the river attributes and the *status quo* effects was rejected. The same result was derived for the Suir models with a χ^2 of 176.54 against the χ^2 critical value of 22.36. As a result, the extended models were also found to be superior to their respective basic versions.

In Model 7, all attribute coefficients were found to be statistically significant and of the expected sign compared to Model 8 where River Life _G, River Life _M, Appearance _A and Cost attributes were the only significant attribute coefficients. However, in Model 8 the SQ coefficient was positive and significant at 1% significance level compared to Model 7 which was marginally significant at 10%. This result confirmed the Suir respondents' preference for the No Change option. The anomaly in the River Life attribute was present even in the extended version of models.

Other findings of Model 7 are that with the exception of age and higher degree, the socio-economic, psychometric, attitudinal and other interaction regressors were found to be significant. In line with *a priori* expectations, respondents who were fully employed, had knowledge of previous or current water policy in Ireland, were unsatisfied about the environmental conditions of the local river and were closer to river's tributary/tributaries were significantly less likely to select the No Change alternative. Interestingly, male respondents, with more dependents, and experiencing less cognitive difficulty were also significantly less likely to choose the No Change alternative. In contrast, respondents who belonged to the middle class, who were not sure if they were really concerned about the environment, who trusted their instinct in making-up their minds and who were concerned about what their social entourage was expecting them to chose, were significantly more likely to choose the No Change alternative. Results from Model 8 show that male and older respondents, with higher level education and more dependents, who belonged to the middles class, who were aware of present or past water policy, who were unsatisfied about the condition of their river, who were concerned about what other people think regarding their choices/preferences, who faced less cognitive burden and surprisingly lived further away were less likely to chose the No Change alternative. On the other hand, respondents who trusted their instincts, who were not sure if they were really concerned about the environment and were full-time employed were significantly more likely to choose the No Change alternative.

At this point it should be noted that for the extended models it was not possible to apply the Hausman–McFadden IIA test. The restricted model could not be estimated due to singularities and hence the only results on the Hausman-McFadden IIA test statistic are those previously performed for the basic models. However, the belief is that the IIA assumption cannot be upheld. As in the previous subsection, the analysis proceeded to examine additional discrete choice models that do not rely on the IIA property. Models 9 and 10 concern NMNL models. As in the case of MNL, examination of the LL function, pseudo-R^2, BIC and the percentage of cases correctly predicted obtained from Models 9 and 10 suggested that some improvement in the NMNL model specification was achieved with the inclusion of individual-specific interaction regressors. An LR-test was conducted in order to assess the performance of the inclusion of the individual related variables in the specification of the NMNL model. The LR-test statistic of 202.54 for the Boyne and 172.24 for the Suir were higher than χ^2 of 23.69 (with 14 degrees of freedom at α=0. 05) and as a result extended Models 9 and 10 produced significantly higher LL function than basic Models 3 and 4.

Inspection of the IV parameters in Models 9 and 10 for the Change attribute revealed that they were within the 0-1 range and significantly different from zero. This result indicates two totally independent choice models for the two branches and hence there exists evidence for the partition used in these models. Furthermore, using the Wald-test and comparing the t-statistics to the critical value of (+/-) 1.96 the IV parameters were found to be statistically different from one. As a result the IV parameters were not statistically equal to either zero or one and were within the 0-1 bound. In this case partitioning the No Change branch was warranted.

Furthermore, Models 9 and 10 were statistically significant with χ^2 of 798.47 and 296.69 for the Boyne and the Suir respectively when compared to a χ^2 critical value of 35.17 with 23 degrees of freedom. The river quality parameters in the case of the Boyne were significant and of the expected sign. Again River Life did not conform to theoretical expectations of decreasing marginal utility of improvement. The Cost attribute was negative and significant while no *status quo* effects were present. In the case of the Suir regarding river attributes, Appearance _S turned positive and significant while River Banks was negative and significant at 5% level. Cost was negative and significant while SQ was positive and significant. Socio-economic, knowledge/attitudinal/belief and psychometric variables for each catchment exhibited almost the same patterns of significance as with MNL Models 7 and 8.

The last two columns of Table 6.5 concern the MMNL specifications for the Boyne and the Suir. Parameter estimates in both models were generated using as before 150 Halton draws. In all MMNL models the river attributes were specified as random with normal distributions.

In Model 11 all river attributes apart from Recreation _S and Appearance _S were positive and statistically significant. Cost was negative and significant while *status quo* effects remained absent. Regarding the observed individual-characteristics there were no differences observed to the previous models (MNL and NMNL) apart from the dependent variable which was no longer significant. Regarding Model 12 all river attributes were significant apart from River Life _G, while again River Banks demonstrated a negative and significant coefficient. Cost remained negative and significant and SQ remained positive and significant demonstrating that *status quo* effects were preserved in a MMNL context. Individual-specific parameters remained of the same significance and sign compared to corresponding MNL and NMNL models apart from cognitive ability, the social concern related variable and the distance variable in the Suir which were no longer significant.

As far as unobserved heterogeneity is concerned, in Model 11 standard deviations of all river attributes were statistically significant at conventional levels, indicating statistically different preferences for these attributes across respondents. The same result holds for the case of the Suir apart from the standard deviation of Recreation _S.

Furthermore, comparing the relative magnitude of the standard deviation parameters with the mean parameters indicated relatively smaller variation in Model 11 than Model 12 in preferences across respondents. Overall both models were statistically significant as χ^2 values of 612.36 and 603.56 for the Boyne and the Suir respectively were higher than χ^2 critical value of 42.55 (with 29 degrees of freedom at $\alpha = 0.05$).

Based on diagnostics (LL function, pseudo-R^2, BIC and the percentage of cases correctly predicted) obtained from Models 11 and 12, these models appeared to be superior to their respective 5 and 6 basic MMNL models. The LR-test was conducted in order to assess the performance of the inclusion of the individual related variables in the specification of the MMNL model. LR-test statistics of 113.26 for the Boyne and 129.94 for the Suir were higher than χ^2 of 22.36 (with 13 degrees of freedom at α=0.05) and as a result the extended models produced significantly higher LL functions than models with only river attributes and *status quo* effects. Finally, Wald tests of extended models coefficient equality are presented in Appendix E (Table E2).

6.2.3 Models' assessment

So far, LR-tests have only been used to determine model improvement as a result of including socio-demographic and other interaction regressors concluding that the inclusion of these observed individual-specific characteristics led to overall improvements in model fit in all considered models. However, in order to assess whether NMNL and MMNL models outperformed their MNL counterparts or whether MMNL were superior to NMNL models, further LR-tests were necessary. Results are reported in Tables 6.6 and 6.7 for both broad versions of models (basic and extended).

An overall observation is that inspection of the following tables suggested that the MMNL models (basic and extended) were superior to their MNL and NMNL model equivalents for both rivers, thereby providing evidence of preference heterogeneity across respondents for the river attributes concerning the local rivers.

The following table summarizes the LL-ratio tests for the basic models reported in Table 6.4. With a χ^2 statistic of 2.56 against a χ^2 critical value of 3.84 (with 1 degree of freedom at $\alpha = 0.05$), it was not possible to conclude that Model 3 is better than Model 1 in the case of the Boyne. However, for the same sample LR-test results reveal that Model 1 was inferior to Model 5 while Model 3 was inferior to Model 5. The overall conclusion is that based on the LR-test results, MMNL Model 5 was found to be superior to other models. The same result is derived for the Suir sample with the only difference that Model 4 was superior to Model 2 compared to the Boyne sample.

Table 6.6: Comparison of reported discrete choice models (basic models)

	Estimated model	Base model	LR-tests	Degrees of freedom	χ^2 critical value at $\alpha = 0.05$
NMNL versus MNL					
Boyne	Model 3	Model 1	2.56	1	3.84
Suir	Model 4	Model 2	12.88	1	3.84
MMNL versus MNL					
Boyne	Model 5	Model 1	210.20	7	14.06
Suir	Model 6	Model 2	188.08	7	14.06
MMNL versus NMNL					
Boyne	Model 5	Model 3	101.82	6	12.59
Suir	Model 6	Model 4	176.02	6	12.59

The predominance of the MMNL model was also deduced by comparing most of the model diagnostics of MMNL models against those of the MNL and NMNL models for both rivers and for both basic and extended models, as summarised in Tables 6.7 and 6.9.

Table 6.7: Comparison of reported discrete choice models (basic models), considering models' diagnostics

Estimated model	LL	Pseudo-R^2	BIC	% correctly predicted
Boyne Model 1	-778.38	0.10	802.58	47
Suir Model 2	-551.54	0.08	574.41	49
Boyne Model 3	-777.10	0.30	803.99	47
Suir Model 4	-545.51	0.12	570.92	49
Boyne Model 5	-673.28	0.30	716.31	47
Suir Model 6	-457.50	0.35	498.15	49

The following table (Table 6.8) summarizes the LL-ratio tests for the extended models reported in Table 6.5. Findings are similar for both samples. Specifically, the NMNL model was superior to the MNL while the MMNL was superior to both the MNL and the NMNL models verifying the above results regarding the basic models. As referred to previously, these findings are in accordance with the improvements observed in the pseudo-R^2 and BIC statistics reported in Table 6.9.

Table 6.8: Comparison of reported discrete choice models (extended models)

	Estimated model	Base model	LL ratio Test	Degrees of freedom	χ^2 critical value at $\alpha = 0.05$
NMNL versus MNL					
Boyne	Model 9	Model 7	5.72	1	3.84
Suir	Model 10	Model 8	7.76	1	3.84
MMNL versus MNL					
Boyne	Model 11	Model 7	124.08	7	14.06
Suir	Model 12	Model 8	141.48	7	14.06
MMNL versus NMNL					
Boyne	Model 11	Model 9	118.36	6	12.59
Suir	Model 12	Model 10	133.72	6	12.59

Hence, although there were additional parameters to be estimated, as measured by the peudo-R^2s, there appeared to be improvement in fit in MMNL models compared to their simpler MNL and NMNL counterparts. Moreover, the BIC statistics indicated that this improvement remained even after penalising for the loss of parsimony for the extended models. This implies the presence of considerable preference heterogeneity and vindicated the move away from the basic MNL model and the simpler NMNL specifications.

Table 6.9: Comparison of reported discrete choice models (extended models), considering models' diagnostics

Estimated model	LL	Pseudo-R^2	BIC	% correctly predicted
Boyne Model 7	-678.69	0.22	737.50	51
Suir Model 8	-463.27	0.23	518.95	57
Boyne Model 9	-675.83	0.37	737.32	51
Suir Model 10	-459.39	0.24	517.60	58
Boyne Model 11	-616.65	0.33	694.18	50
Suir Model 12	-392.53	0.43	465.93	56

6.3 More in depth-analysis of discrete choice models

By using different discrete choice model specifications, the objective of this section is to extend the analysis conducted in the previous section in order to explore further respondents' preferences for river improvements. Due to sample size and quality of data considerations the analysis that follows focuses on the Boyne sample. In addition, based on previous results *status quo* effects are omitted without influencing models output and model specifications do not incorporate the socio-demographic, psychometric or knowledge/attitudinal/belief characteristics of the individuals for simplification purposes. This approach was adopted because the focus of this section was to explore the trade-offs between the attributes under the prism of different specifications avoiding complex relationships.

The discrete choice models reported in the previous section identified the existence of heterogeneity among respondents for the river attributes. Further, given the fact that the model performance indicators vindicated the use of MMNL specifications over the basic MNL and NMNL model specifications, analysis of the discrete choice experiments in this section investigates further the MMNL model but also employs models that look at different forms of heterogeneity.

Table 6.10 presents the different specifications that were considered starting from extensions of MNL such as the HEV model. The heteroskedastic model avoids the IIA restriction of the MNL model by allowing the random components of utilities of the different alternatives to have unequal scale parameters. Unequal variances of the random components are likely to occur when the variance of an unobserved variable that affects choice is different for different alternatives. The IIA assumption holds only if the scale parameters of all the alternatives are equal, in which case the heteroskedastic model collapses to the MNL model.

Since the HEV allows different scale parameters across alternatives, the parameters to be estimated in the heteroskedastic model are the parameter vector β and the scale parameters of the random component of each of the alternatives (one of the scale parameters is normalized to one for identification). The t-statistics for the scale parameters in the heteroskedastic models are with respect to a value of one. When the p-value is 0 it means that there are differences across choices. The HEV 1 indicated that the scale parameter of the random error component associated with the No Change /Option A utility was significantly smaller than that associated with the Option B utility (the scale parameter of the random component of the Option B utility is normalized to one). Therefore, the heteroskedastic model HEV 1 suggested unequal cross-elasticities among the alternatives and implied that there was some unobserved variable whose values varied between alternatives. Furthermore, the HEV 1 model suggested (relative to MNL) a higher sensitivity of respondents to all attributes except from recreation which was no longer significant.

A comparison of the MNL and the HEV 1 is based on the LL ratio test where the null hypothesis is defined as equality in the random terms of the utility function across alternatives. The rejection of the MNL model (with a χ^2 of 6.66 at 5% with 2 degrees of freedom against a test statistic of 8.11) confirmed the assumption about unequal variances of the random components.

Hence, HEV 1 allowed the variance to vary and the hypothesis that the variances in the utility functions were all equal was tested using a Wald test. A test statistic of 13 rejected the null hypothesis and confirmed the previous results. On the other hand, HEV 2 allowed variances to vary across utilities and with other variables, for example full-employment and cognitive ability. With a LR-test value of 49.72 and critical value of 5.99 the null hypothesis that the two variables were not significant determinants of the variances was rejected. Hence, heterogeneity was observed across respondents and choices. Furthermore, comparing the diagnostics between HEV 1 and HEV 2 it was concluded that the second model was superior to the first since improvement in all measures (LL function, pseudo-R^2, correctly predicted choices and more importantly in BIC) was observed.

Table 6.10: Further analysis for Boyne

	HEV 1	HEV 2	Error Components Logit Model 1	Error Components & Random Parameters	MMNL Triangular Constraint Distr.
River Life _G	1.132 (3.645)***	0.460 (2.856)***	0.651 (2.445)**	0.812 (2.450)**	1.268 (5.345)***
River Life _M	1.298 (4.829)***	0.492 (2.947)***	1.036 (4.474)***	1.264 (4.522)***	1.451 (7.134)***
Appearance _A	1.406 (4.696)***	0.546 (2.965)***	1.597 (7.113)***	1.936 (6.617)***	1.088 (6.862)***
Appearance _S	1.158 (3.737)***	0.459 (2.711)***	1.182 (6.061)***	1.313 (4.805)***	0.785 (4.796)***
Recreation _A	0.162 (0.620)	0.074 (0.707)	0.903 (5.499)***	1.100 (3.923)***	0.203 (1.170)
Recreation _S	-0.031 (-0.138)	0.007 (0.086)	0.710 (5.316)***	0.819 (4.237)***	0.145 (1.045)
River Banks	0.964 (4.912)***	0.343 (2.793)***	1.100 (9.563)***	1.324 (6.748)***	0.834 (7.504)***
Cost	-0.038 (-5.730)***	-0.013 (-3.254)***	-0.025 (-6.090)***	-0.029 (-4.620)***	-0.046 (-8.481)***
Scale par. of Ext. Value Dist.					
No Change	-0.334 (-3.127)***	0.642 (6.024)***			
Option A	-0.457 (-3.769)***	0.530 (4.291)***			
Option B	Fixed par.	Fixed par.			
Random latent effects					
No Change			3.769 (1.539)	4.822 (6.787)***	
Combined option A/B			1.984 (0.446)	1.007 (0.434)	
Std.Dev for H.E.V. distrib.					
No Change	1.925 (6.233)***				
Option A	2.364 (4.466)***				
Option B	Fixed par.				
Heterogeneity in Scales of Ext. Value Distns					
Cognitive		0.038 (3.273)***			
Fullempl		0.365 (2.827)***			
St. Deviations					
River Life _G				0.176 (0.079)	1.268 (5.345)***
River Life _M				0.314 (0.309)	1.451 (7.134)***

Appearance _A				0.538 (0.882)	1.088 (6.862)***
Appearance _S				1.363 (3.639)***	0.785 (4.796)***
Recreation _A				0.926 (1.506)	0.203 (1.170)
Recreation _S				0.208 (0.211)	0.145 (1.045)
River Banks				1.382 (3.416)***	0.834 (7.504)***
Cost					0.046 (8.481)***
Diagnostics:					
LL	-773.55	-748.69	-643.54	-627.87	-749.61
χ^2	360.08	383.43	620.10	651.43	407.95
Pseudo-R^2	0.188	0.203	0.325	0.341	0.213
BIC	800.44	780.88	670.439	673.60	771.12
Correctly predicted	47%	48%	44%	44%	48%
Observations	868	856	868	868	868
# of respondents	217	214	217	217	217

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%.

The previous model assumed random preference heterogeneity of degree zero in systematic utility and was only able to partially relax the IID assumption of MNL. Analysis progresses to variations in the mixed logit group of models and the next model considered is the Error Components Logit Model. In this model a person specific random effect is added. Taking advantage of the panel dimension (the same person is observed four times in each choice situation regarding the local river) it is generally assumed that the effect does not change from one choice setting to the next. This model provides an alternative approach to building cross choice correlation. The introduced error components accounts for unobserved, individual choice specific variation and hence introduces heteroskedasticity and correlation across alternatives in the unobserved portion of utility. The variance reported in Table 6.10 captures the magnitude of the correlation. It plays an analogous role to the inclusive value coefficient of NMNL models. As explained in more detail in Train (2009) the correlation between any two alternatives within nest k is $\sigma_k/(\sigma_k + \pi^2/6)$, where σ_k is the variance of each nest's error component.

In this context of analysis with 150 Halton draws, none of the error components was statistically significant which shows that there was not a substantial amount of preference heterogeneity (unobserved attributes) associated with the alternatives. It should be noted that Option A and Option B belong to the same nest while No Change is a second nest following the NMNL specification. According to the results of this model, all river attributes were significant and of the expected sign exhibiting as well a higher sensitivity compared to the previous models.

An interesting extension of the previous model is that of a mixed logit-error component model presented in column four, that accounted not only for error components structures combining Option A and Option B but also for random parameters. The results showed that the error component for the combined alternatives A and B was not statistically significant while it was significant for the No Change alternative revealing alternative specific variance heterogeneity (heteroskedasticity) in the unobserved effects of the particular alternative. Furthermore, it is observed the existence of heterogeneity in the parameter estimates over the sampled population around the mean parameter estimate of River Banks and Appearance _S attributes.

Regarding the MMNL reported in column 6 following Hensher and Greene (2003) a bounded triangular distribution was used in which the location parameter was constrained to be equal to its scale. Such a constraint forces the distribution to be bounded over a given orthant, the sign of which is the same as the sign of the location parameter. Constrained triangular distributions were used for all river attributes and the Cost attribute. It is regarded that this procedure restricts the sign of the distribution to one side of zero and avoids behaviourally inconsistent estimates (such as WTP values) due to the range of taste values over which distributions such as normal or log-normal span, producing wrong signs and having fat tails. This is very important when taste intensities are expected to be positive *a priori*. As emphasised in Hensher *et al.* (2005) in order to derive behaviourally meaningful WTP values from random parameter estimates, the distributions from which random parameters are drawn must be constrained. In particular, "constraining the standard deviation parameter estimate to that of the mean of the random parameter for a triangular distribution guarantees non-negative WTP measures" (Hensher *et al.*, 2005, p.689). Shuffled Halton sequences with

150 draws were specified in preference to regular Halton draws because they provide better coverage of the distribution space when estimating a large number of parameters (Bhat 2003; Train 2003) and avoid the high correlation that can occur between sequences constructed from higher primes, and thus sequences used in higher dimensions (Bhat 2003). The results from this model specification were significant estimates of the expected sign for all river attributes except Recreation. In addition, most of the attributes were estimated with much higher precision, as reflected by the *t*-ratios, compared to the previous models. Finally, the relative dimensions of the parameter estimates of the significant attributes, apart from River Life, corresponded with decreasing marginal utility.

An alternative model used in accounting for unobserved preference heterogeneity is the LCM. A brief introduction to LCM was given in Chapter 3. LCM entails a simultaneous estimation process that employs joint probability of whether a particular respondent chooses an alternative and the probability of a respondent belonging to a class of individuals which share identical characteristics and preferences (Swait 1994). Within classes, choice probabilities are estimated in a manner analogous to MNL inducing the IIA property and the reported βs are specified as a class specific parameter vector. Hence, the model assumes that respondent characteristics affect choice indirectly through their impact on segment/class membership which is characterised by relatively homogenous preferences for this particular segment/class of individuals. These segments, however, differ substantially in their preference structure and this is where preference heterogeneity takes place. After extensive testing with the respondent characteristics that were collected in the survey, the variables that affected segment membership the most are included in the model and reported in Table 6.11.

Table 6.11: Further analysis for Boyne – Latent class model

	Latent Class 1		Latent Class 2		Latent Class 3	
River Life _G	4.805	(4.137)***	-0.220	(-0.829)	-17.511	(-0.004)
River Life _M	2.175	(3.191)***	1.061	(4.569)***	0.383	(0.500)
Appearance _A	3.784	(3.964)***	2.256	(12.016)***	-0.954	(-1.434)
Appearance _S	4.923	(4.870)***	0.940	(5.206)***	-3.732	(-4.145)***
Recreation _A	1.948	(2.678)***	1.491	(7.402)***	1.764	(1.698)*
Recreation _S	-1.775	(-3.378)***	1.627	(11.077)***	0.332	(0.489)
River Banks	3.464	(5.253)***	0.908	(7.080)***	-2.243	(-4.076)***
Cost	0.008	(0.560)	-0.052	(-9.315)***	-0.051	(-2.209)**
Constant	0.408	(0.444)	0.892	(2.010)**	Fixed Parameter	
Gender	0.476	(0.799)	0.802	(1.405)	Fixed Parameter	
Fullempl	1.833	(2.753)***	1.510	(2.307)**	Fixed Parameter	
Distance	-0.334	(-2.150)**	-0.076	(-1.396)	Fixed Parameter	
Nsconserned	-17.391	(-0.013)	-2.854	(-2.524)**	Fixed Parameter	
Unsatisfqual	1.849	(2.802)***	1.421	(2.201)**	Fixed Parameter	
Socialcon	-0.568	(-1.024)	-1.204	(-2.269)**	Fixed Parameter	
Cognitive	0.011	(0.330)	-0.0005	(-0.036)	Fixed Parameter	
Diagnostics:						
LL	-551.06					
χ^2	805.05					
Pseudo-R^2	0.422					
BIC	658.66					
Correctly predicted	78%					
Observations	868					
# of respondents	217					

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%.

For the selection of the optimal number of classes different criteria were used such as LL, R^2, AIC and BIC. Results are presented in Table 6.12.

Table 6.12: Criteria for determining the optimal number of segments

No. of Segments	LL	R^2	Parameters (P)	AIC	BIC
1	NA	NA	NA	NA	NA
2	-622.27	0.347	24	1196.55	686.83
3	-551.06	0.422	40	1022.12	658.66
4	-537.92	0.435	56	963.85	688.56

Note: estimated variance matrix of estimates was singular for 1 segment

The LL and R^2 statistics were improved adding one more segment to the initial two segments, supporting the presence of multiple segments in the sample. The four segments with too many degrees of freedom could not be supported by the data. Hence, the choice was between two or three segments. The three segments solution provided the best fit to the data, since both AIC and BIC statistics decreased and R^2 increased, and were selected as the best estimate of classes. Ideally segment selection requires a balanced assessment between measures of goodness-of-fit and parsimony.

In the reported three segments model in Table 6.11, the first part of the table displays the utility coefficients of river attributes, while the second part reports segment membership coefficients. The segment membership coefficients for the third segment were normalised to zero in order to identify the remaining coefficients of the model and all other coefficients were interpreted relative to this normalised segment. For segment one, the utility coefficients for all of the four river attributes were significant. However, Recreation _S had a negative sign and the Cost attribute was insignificant. The segment membership coefficients revealed that being employed full-time and being unsatisfied about the environmental condition of the river increased the probability that the respondent belonged to the first segment. The opposite was true for respondents who were living further away from the river.

For the second segment all river attributes but River Life _G and Cost were significant. The segment membership coefficients showed that being employed full time and being unsatisfied about the environmental condition of the river increased the probability that the respondent belonged to the second segment. The opposite effect was observed for respondents who were not sure whether they were concerned about the environment and those who cared about what their social environment would like them to choose. In the third segment the only positive and significant river attribute was Recreation _ A, while apart from the Cost Appearance _S and River Banks attributes, showed also a decrease in the likelihood that respondents in segment three would choose an option/alternative with higher levels of these attributes. Finally, it was found that 39% of the sample belonged to the first segment, 47% to the second, and 14% belonged to the third segment.

General conclusions from this analysis are that the data contained information that the MNL model was not flexible enough to bring to light. It is easy to identify the models in the previous table that provided a better fit than the MNL of the previous section. At first glance it seems that the LCM had the better fit while other findings were that heterogeneity in scale and random latent effects were present and had an impact on the attributes' coefficients magnitude, statistical significance and precision of calculation.

6.4 Benefit transfer

Previous research in the area of estimating the benefits of water quality improvements with a scope to explore if benefits are transferable is not extensive and few studies have used CE in a BT context in the field of environmental valuation. A brief overview of related studies was offered in Subsection 2.2.4 of Chapter 2. In this section, the focus is more on providing an introduction to the method and presenting the results from its application in the context of the current study.

6.4.1 A short overview

The fact that gathering primary site-specific data is costly and time-consuming has made BT a more and more popular alternative for the valuation of ecosystem goods and services. BT method uses existing economic value estimates from one location to another similar site in another location. In particular, it concerns an "application of values and other information from a 'study' site where data are collected to a 'policy' site with little or no data" (Rosenberger and Loomis, 2000, p.1097).

Bergland *et al.* (1995) discussed three main approaches to BT: (i) the transfer of the mean household WTP (ii) the transfer of an adjusted mean household WTP and, (iii) the transfer of the demand function. Hence, while the first approach assumes similarity in good and socio-economic characteristics between the study and target site, the other two approaches attempt to adjust the mean WTP and re-calculate it respectively, in order to account for differences between the two sites in terms of environmental characteristics and/or socio-economic characteristics. More particularly, in the case of unadjusted mean value transfer the H_0 is: $WTP_{\text{study site (s)}} = WTP_{\text{policy site (p)}}$. On the contrary, the adjusted value transfer tests the hypothesis: *predicted* $WTP_p(\beta_s, X_p) = WTP_p$, where predicted $WTP_p(\beta_s, X_p)$ is the WTP at the policy site estimated using the parameters of the benefit function of the study site (β_s) and the X values (site attributes, socio-economic characteristics, *etc.*). In the case of benefit function transfer, the value function estimated for the study site is transferred to the policy site and the relevant test concerns the comparison of function parameters between sites: $\beta_s = \beta_p$.

It should be noted as well that meta-analysis can be used to inform BT processes (Hanley *et al.*, 2006a). When data are pooled across study sites to produce a BT model for predicting policy site values, the test is: $\beta_{s+p} = \beta_s$ and $\beta_{s+p} = \beta_p$ where, β_{s+p} are the parameters of the pooled regression models.

Generally, the benefit function option seems to be preferred as among other reasons it accounts for differences in site characteristics and human populations between sites. However, function transfers are "limited by quality and availability of primary research, limited consensus on performance and validity of types of function transfers and lack of consensus on how to generate functions" (Rosenberger and Johnston, 2009). Furthermore, thinking in terms of Transfer Error (TE), function transfer does not seem to perform better than unit value transfer as shown in Table 6.13 which presents an overview of convergent validity results. TE is defined as the percent difference between the transferred-predicted (WTP_T) and policy site-observed primary estimate (WTP_P):

$$TE = \frac{|WTP_T - WTP_P|}{WTP_P} x100\%$$

Table 6.13: Convergent validity results

Source	Resource/Activity	Value transfer percent error	Function transfer percent error
Loomis (1992)	Recreation	4 – 39	1 – 18
Parsons and Kealy (1994)	Water/Recreation	4 – 34	1 – 75
Bergland *et al.* (1995)	Water Quality	25 – 45	18 – 41
Kirchhoff *et al.* (1997)	Whitewater Rafting	36 – 56	87 – 210
	Birdwatching	35 – 69	2 – 35
Brouwer and Spaninks (1999)	Biodiversity	27 – 36	22 – 40
Vanden Berg *et al.* (2001)	Water Quality		
Individual sites		1 – 239	0 – 298

Pooled data (multi-state)		0 – 105	1 – 56
Pooled data (state-level)		3 – 57	0 – 39
Pooled data (contaminated sites)		3 – 100	2 – 50
Chattopadhyay (2003)	Air Quality		
N= 1522 (similar subgroups)		32 – 58	32 – 58
Ready *et al.* (2004)	International Health	20 – 81	20 – 83
Santos (2007)	Landscape Values	15 – 81	21 – 76
Lindhjem and Navrud (2008)	Forest Values	1 – 482	2 – 266

Source: Adaptation from Brouwer (2000) cited in Rosenberger and Johnston (2009)

It should be noted that the comparison of transfer estimates to a primary study estimate available for the site in question (WTP_{TRUE} -$WTP_{TRANSER}$ = 0 that is TE equal to 0), is a typical way for assessing validity. In this context of convergent validity testing, the smaller the difference the higher the transfer accuracy. However, this null hypothesis of no difference has been criticized based on the fact that values estimated from two different contexts will differ according to theory and prior information. As a result, the null hypothesis should declare that values will differ (Kristofersson and Navrud, 2005). Furthermore, the fact that the degree of accuracy depends on the task at hand and the policy context and finally the evidence that less efficient statistical estimates with large standard errors lead to increased transferability (Kristofersson and Navrud, 2005; Johnston and Duke, 2008) have undermined the reliability of conventional approaches used so far and have promoted the development of alternative tests such as equivalence testing (Kristofersson and Navrud, 2005). The authors argued that this approach has three advantages over traditional testing when testing for validity. Those are the fact that it assumes difference as the null hypothesis, it results in more reliable conclusions about transferability, and it explicitly incorporates a judgement about what constitutes a policy significant difference in values. Although this method has not seen yet a widespread use in economics, a part of the literature is considering its application within BT (Hanley *et al.*, 2006b; Johnston, 2007; Johnston and Duke, 2009). The supporters of the test argue that it is superior to traditional testing since it combines statistical and policy significance into one test while defining an acceptable transfer error prior to conducting the validity test. In this context, according to the intended policy use the level of acceptable transfer error will be chosen (Rosenberger and Johnston, 2009).

6.4.2 Methodology used in the survey

In this study, three BT tests were used: (i) the equivalence of choice models parameters (ii) the equality of implicit prices and, (iii) the equivalence of CS estimates for different policy designs. For the first test the Swait Louviere LR-test of parameter equality was performed. Comparison of the parameters of choice models from both catchment areas requires accounting for scale parameter in order to avoid confoundment that derives from the statistical assumption that the error terms are Gumbel distributed. Hence, the pooling of two different data sets is problematic since the estimated parameters are confounded with the respective scale parameters. In particular, the values of the estimated parameters β_s and β_p are equal to the values of the true parameters β_{ts} and β_{tp} multiplied by their scale parameters ($\beta_s = \lambda_s \beta_{ts}$ and $\beta_p = \lambda_p \beta_{tp}$).

As a result, benefits function transfer in CE requires a comparison of the underlying β vectors once differences in scale factors across data sets have been taken into account. Swait and Louviere provided a re-scaling procedure in order to achieve the above comparisons. Hence, the null hypothesis is that of equal scale parameters and the form of the LR-test is the following: LR= - 2[$LL_{X1/2}$ - (LL_{X1}+LL_{X2})] where $LL_{X1/2}$ is the log-likelihood value attached to the model of the stacked data set at the optimum level of the scalar value and LL_{X1} and LL_{X2} are the log-likelihoods of the models of the individual data sets. This LR statistic follows an asymptotic χ^2 distribution with degrees of freedom that equal the number of parameters across the three models involved. If the χ^2 statistic is smaller than the calculated statistic it means that the hypothesis that the vector of parameters are equivalent across the two data sets should be rejected and hence, the differences in the scale parameter are not enough to account for variations in the coefficients. As a result, after differences in the scale parameters have been accounted for, the variations in the coefficients are still significant and the choice models of the two sites are different.

Next, comparison of implicit prices between the two regions was attempted. For this second test the Poe *et al.* (1994) test of equality of means was performed. As it has been noted, "[a]lthough implicit prices are useful to policymakers when defining priorities for policy design, they do not represent valid welfare measures to be used in cost-benefit analysis...Moreover, compensating surplus calculations allow combinations of attribute changes to be considered" (Colombo and Hanley, 2008, pp.137-138). In this latter case the null hypothesis is H_0: $CS_{j\ \text{Site A}} = CS_{j\ \text{Site B}}$ where CS_j is the CS for the scenario j.

The CS welfare measure, measures the change in income that would make an individual indifferent between the initial (lower environmental quality) and subsequent situations (higher environmental quality) assuming the individual has the right to choose the initial utility level. This change in income reflects the individual's WTP to obtain an improvement in environmental quality. A more explicit description of welfare measurement was presented in Chapter 3.

Following Boxall *et al.* (1996) and Morrison *et al.* (1998), the following equation was employed:

$$CS = \{-1/(|\beta_M|)\}(V_0 - V_1)$$

where β_M is the coefficient of the monetary attribute and is defined as the marginal utility of income, and V_0 and V_1 represent initial and subsequent states, respectively. As a result, the indirect utilities of respondents were calculated using coefficients of significant variables and the sample means of socio-economic variables.

For this last test the definition of scenarios used in the estimation was firstly required. Then the Poe *et al.* (1994) test was employed to test CS mean equality for these scenarios. It should be noted that the Swait and Louviere test is not necessary when comparing the implicit prices or the welfare measures of multiple datasets as the scale parameter of each data set cancels out in the calculations. However, for each scenario it is possible to calculate the TE, as defined in Subsection 6.4.1, using the model parameters of one catchment and the site attributes and socio-demographic characteristics of the other catchment (*i.e,* by adjusting the value estimates as in predicted $WTP_p(\beta_s, X_p) = WTP_p$). Both direct (unadjusted) value transfer and function transfer can be tested.

Since this study was not primary designed for BT application there is *a priori* information that existing differences may have an effect on the transferability of estimates. At this point it should be emphasised that "the benefits-transfer error depends critically on which site is chosen as study site where the original valuation exercise is carried out" (Colombo and Hanley, 2008, p.140). Hence, in this study BT was attempted from both directions of sites. For the analysis, socio-economic and attitude variables were included in the model specification since they have been found to improve the accuracy of BT along with psychometric variables.

6.5 Benefit transfer results

The BT exercise presented in this section was based on the two parallel surveys conducted in the two catchments. Favourably to BT, the two watersheds present similar environmental and physical features in all aspects but River Banks where the Boyne HA seems to face more problems regarding this attribute. Both catchments face degradation that is representative of rivers condition in Ireland although the Suir has a higher percentage of "good" river quality compared to the Boyne. In addition, in both HAs environmental quality will be similarly assessed according to WFD guidelines. Hence, in both catchments the included attributes coincide with respondents concerns, as these were revealed during focus groups and the pilot survey, and coincide with river managers' and experts' implementation of the WFD. However, differences in welfare measures are expected to be found not only in population (their preferences, beliefs and socio-economic factors) but also in site characteristics. It is also reminded that different designs were employed in each catchment in order to account for different priors affecting also welfare measures.

In Hanley *et al.* (2006a) it was noted that from a statistical point of view, the assessment of BT concerns testing for the equality of parameters and WTP values 'across equations'. As the authors pointed out, applicability of BT is based on the extent to which data from different samples can be pooled and therefore pooling is 'statistically acceptable'. As the two samples of the survey come from different catchments and data are generated from different experimental designs the issue of accounting of scale is of paramount importance.

Consequently, the first test of interest is the equivalence of choice model parameters. Hence, an LR-test was used to determine whether this null hypothesis should be rejected. The LL of the MNL combined model, which is not reported here for parsimony, is -1517.66. The test statistic is therefore 375.48 and the critical value given 9 degrees of freedom is 16.92. In the case of MMNL the LL of the combined model is -1256.01 and the test statistic is 250.46. Hence, we reject the null hypothesis and conclude that the two models are not equivalent overall. The next step was to examine whether the two models are equivalent after allowing for differences in variance. Table 6.14 shows the combined and rescaled MNL and MMNL models for the basic specification, their diagnostics and the scale parameter that maximizes LL. The test statistic for the LR-test of parameter equality (Swait and Louviere) is also calculated and compared against a critical χ^2 value. It should be noted that although the emphasis is on the MMNL model, MNL model results are also reported for comparison purposes in order to explore the sensitivity of the test to model specification. For the MMNL estimation 150 Halton draws and normal distributions for the river parameters were used, while the panel dimension of the data was also considered. The scale parameter of the Boyne dataset was normalised to one. BIOGEME (Version 1.7) was used for the estimation of discrete choice models and the performing of the test.

Table 6.14: Swait – Louviere test for local river (basic models)

	Joint MNL		Joint MMNL independent coefficients with SQ		Joint MMNL independent coefficients without SQ	
River Life _G	0.146	(2.17)**	1.00	(2.99)***	0.822	(4.95)***
River Life _M	0.293	(3.24)**	1.75	(5.28)***	2.01	(7.19)***
Appearance _A	0.308	(3.14)***	1.37	(4.58)***	1.21	(6.14)***
Appearance _S	0.101	(1.69)*	0.307	(1.15)	0.053	(0.30)
Recreation _A	0.081	(1.68)*	0.340	(1.14)	0.494	(2.64)**
Recreation _S	0.024	(0.61)	0.189	(0.84)	0.159	(1.71)*
River Banks	0.049	(1.18)	0.092	(0.37)	0.296	(2.01)**
Cost	-0.008	(-3.67)***	-0.059	(-7.39)***	-0.070	(-8.90)***
SQ	0.413	(3.43)***	0.579	(2.07)**		
St. Dev. of parameters						
River Life _G			1.93	(3.69)***	3.07	(8.27)***
River Life _M			2.78	(6.55)***	3.48	(8.69)***
Appearance _A			2.96	(6.16)***	2.49	(7.73)***
Appearance _S			2.47	(6.27)***	2.22	(7.86)***
Recreation _A			2.42	(4.24)***	2.99	(6.98)***
Recreation _S			1.13	(3.36)***	0.737	(5.48)***
River Banks			3.56	(6.97)***	3.24	(8.63)***
LL	-1506.40		-1257.65		-1249.10	
R^2 square	0.093		0.243		0.248	
χ^2	309.39		806.89		823.99	
# of observations	1512		1512		1512	
# of individuals	378		378		378	
Scale H_0: $\beta_{1\ model} = \beta_{2\ model} = \beta_{pooled}$	Scale ratio: 4.55, t-test=3.12*** p-value=0.00 Rob. t-test= 1.41, p-value=0.16		Scale ratio: 1.63, t-test=1.48 p-value= 0.14 Rob. t-test =1.13, p-value=0.26		Scale ratio: 7.96, t-test=2.27** p-value=0.02 Rob. t-test =1.87* p-value=0.06	

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%

To formally test the hypothesis of identical preferences in the two catchment samples, a LR-test for the nested models was conducted. The hypothesis tested was H_0: β_1 model

$=\beta_2$ model=β_{pooled} and the likelihood test statistic was LR = -2 [L_{pooled} - (L_1 + L_2)]. A LR-test value of 352.96 for MNL and of 253.74 for MMNL showed that the hypothesis of identical preferences (identical parameter equality) across the two samples could be rejected, even after rescaling since the test values were greater than the 27.6 tabulated critical χ^2 value at the 5% level (with 17 d.f.) for the MMNL and the 18.3 value at the 5% level (with 10 d.f.) for the MNL. As a result, even after adjusting for scale it can be concluded that the choice models of the two catchments were different. Inequality in parameters demonstrated that residents of subsequent catchments valued differently environmental improvements in their river and considering this finding indirect utility functions were different and a BT was not statistically advisable.

In addition, a robust t-test for the relative scale parameter showed that none was significantly different from one, indicating that the scaled pooled model does not improve upon a naively pooled model. It should, however, be noted that this analysis is sensitive to the specification of the models. By omitting the SQ whose significance varies across sites, the scale factor parameter is significant although only at 10% level (last column Table 6.14). If the MMNL model without SQ was to be considered findings would have shown that data from the Suir's sample had more random noise (since value for scale parameter was higher than one) than the Boyne sample and that the scaled pooled model would improve upon the non-scaled model.

The same test was performed considering models that accounted for observed heterogeneity. The equivalence of choice model parameters without rescaling was rejected as the test statistics were 318.08 for the MNL model[10] and 164.28 for the

[10] The LL of the MNL combined model is -1301.393, while for the MMNL is -1138.073.

MMNL model against a critical χ^2 value of 33.9 for MNL (with 22 d.f.) and 42.6 for MMNL at the 5% level (with 29 d.f.). Table 6.15 reports the results which showed that even after including individual characteristics and allowing for differences in variance, the choice models of the two catchments were different. The test statistics after adjustments were 285.16 and 284.92 for the MNL and MMNL models respectively. Nevertheless, some evidence of scale factor statistically significant difference is also reported in the table.

Table 6.15: Swait – Louviere test for local river (extended models)

	Joint MNL		Joint MMNL independent coefficients	
River Life _G	0.323	(3.04)***	0.869	(3.29)***
River Life _M	0.534	(5.09)***	1.450	(5.29)***
Appearance _A	0.540	(5.41)***	0.967	(3.98)***
Appearance _S	0.228	(2.56)**	0.084	(0.35)
Recreation _A	0.174	(2.31)**	0.480	(1.88)*
Recreation _S	0.019	(0.30)	0.133	(0.76)
River Banks	0.120	(1.89)*	0.211	(0.95)
Cost	-0.014	(-6.19)***	-0.047	(-7.83)***
SQ	1.61	(5.74)***	1.32	(1.39)
GenderSQ	-0.118	(-1.63)	-0.520	(-1.84)*
AgeSQ	-0.072	(-2.63)**	-0.081	(-0.75)
HdegreeSQ	-0.444	(-4.12)***	-0.900	(-2.80)**
DepntSQ	-0.167	(-4.04)***	-0.460	(-3.63)***
FullemplSQ	0.030	(0.40)	-0.131	(0.65)
MiddleclSQ	-0.509	(-3.26)***	-0.712	(-1.35)
DistanceSQ	0.006	(0.74)	0.076	(1.73)*
WaterpolicySQ	-0.852	(-3.79)***	-2.20	(-3.97)***
NsconsernedSQ	0.701	(2.92)***	2.72	(3.27)***
UnsatisfqualSQ	-2.31	(-10.02)***	-3.72	(-7.12)***
InstinctSQ	0.240	(2.70)**	0.749	(2.16)**
SocialconSQ	-0.074	(-0.98)	0.343	(1.22)
CognitiveSQ	0.002	(0.35)	0.060	(2.20)**
St. Dev. of parameters				
River Life _G			1.630	(3.62)***
River Life _M			2.050	(5.67)***
Appearance _A			1.700	(5.02)***
Appearance _S			1.880	(5.13)***
Recreation _A			1.930	(4.25)***
Recreation _S			0.616	(1.97)**

River Banks		2.330 (6.17)***
LL	-1284.54	-1151.64
R^2	0.206	0.288
χ^2	665.233	931.016
# of observations	1472	1472
# of individuals	368	368
Scale		
H_0: $\beta_{1\ model} = \beta_{2\ model} = \beta_{pooled}$	Scale ratio: 2.53*** , t-test=3.51, p-value=0.00 Rob. t-test= 1.56, p-value=0.12	Scale ration: 1.52*, t-test=1.84 p-value=0.07 Rob. t-test= 1.58, p-value=0.12

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%

The second test focuses on the equality of implicit prices. The resulting values were estimated as the marginal rates of substitution between the river attributes and the expected annual Cost attribute. These were calculated as the negative ratio between the population moments of the river attributes and the expected annual Cost attribute, as shown in Chapter 3. Table 6.16 provides estimates of implicit WTP for both levels of improvements from the No Change level for all river attributes (in € per year) for the MNL and MMNL discrete choice model specification. The table also reports in parenthesis the 95% confidence intervals estimated using the Krinsky and Robb procedure with 1000 draws, whilst the last columns show the approximate significance levels resulting from the Poe, Severance-Lossin and Welsh test of equality of means.

WTP estimates for attributes that were not found to be significantly different to zero, at $\alpha = 0.05$, are expressed as zero. Before performing the BT test, it is advisable to check if, within the same catchment, the MNL and MMNL models give the same estimates. What is observed from the relative columns of Table 6.16 is that in the Boyne catchment the mean value of implicit prices of the MMNL model were lower than for the MNL, but they did not differ statistically at the 5% significant level. This suggests that preference heterogeneity in this case was likely not a factor of much importance and the prices were robust. In the Suir catchment mean values of implicit prices of the MMNL model were lower and significant at the 5% level compared to MNL for the case of River Life attribute. The implicit prices, when calculation was possible, for the considered attributes did not differ significantly between the two catchments in the MNL model. So while all three implicit prices were equal in the MNL model, only Appearance _ S and Recreation were equal in the MMNL model. However, it is noteworthy that the inclusion of taste heterogeneity caused for example the implicit price of the River Life _M to differ between the two catchments under the MMNL specification. If this source of variation is ignored, as under the MNL specification, it could lead to a misleading BT.

Overall, according to the findings of this test, results are partially supportive of the use of implicit prices for BT, a result found in previous studies like that of Morrison *et al.* (2002). In addition, although the preference equality indicated by the likelihood ratio tests was rejected, it seems that this result was not strong enough to translate into significant differences between all the attribute-specific WTP estimates. Hence, even though the LR tests may initially suggest preference inequality, the WTP estimates suggest that this result is not uniformly applied when it comes to WTP measures. It is argued that different coefficients are not necessarily translated to overall different implicit prices as the calculation of the latter involves the ratio of the coefficients. As a result, it could be for example that the combination of attribute coefficient value and cost coefficient are different across the catchments but when dividing one by the other the result is a similar implicit price. Furthermore, deviations of results between tests are partly due to the power of the employed tests.

Table 6.16: Implicit prices (€ per household/year) and confidence intervals (extended models)

	MNL		MMNL		$IP_{Boyne\|MNL} = IP_{Suir\|MNL}$	$IP_{Boyne\|MMNL} = IP_{Suir\|MMNL}$	$IP_{Boyne\|MNL} = IP_{Boyne\|MMNL}$	$IP_{Suir\|MNL} = IP_{Suir\|MMNL}$
	Boyne I.P	Suir I.P	Boyne I.P	Suir I.P				
River Life _G	30.14	16.05	28.59	-5.15	0.113	0.003	0.438	0.031
	(16.35, 43.78)	(-1.39, 36.48)	(12.60, 47.36)	(-17.72, 9.12)				
River Life _M	40.77	36.55	37.19	12.98	0.368	0.001	0.361	0.012
	(29.04, 51.98)	(19.41, 55.61)	(25.56, 50.74)	(0.91, 23.76)				
Appearance _A	42.13	28.35	36.24	16.27	0.152	0.056	0.348	0.110
	(23.66, 67.67)	(13.56, 42.92)	(16.18, 64.35)	(4.40, 30.42)				
Appearance _S	27.73	0.00	14.50	10.87	NA	0.407	0.155	NA
	(12.02, 48.18)		(-2.07, 39.14)	(-3.13, 20.97)				
Recreation _A	20.87	0.00	22.33	12.29	NA	0.220	0.538	NA
	(6.22, 40.10)		(1.93, 47.56)	(-1.64, 22.54)				
Recreation _S	12.37	0.00	1.97	7.44	NA	0.243	0.140	NA
	(0.60, 26.06)		(-11.33, 17.34)	(-0.20, 14.62)				
River Banks	30.33	0.00	27.50	-6.03	NA	0.001	0.397	NA
	(18.61, 46.45)		(11.61, 45.39)	(-16.78, 1.05)				

Note: NA= Non-applicable

The final test to be considered in the context of this short BT task is the most policy relevant test since it focuses on the equivalence of CS estimates for different policy designs. As stated previously, comparing the CS estimates requires the definition of the scenarios used in the estimation, since CE offers the possibility to calculate multiple estimates of welfare change by changing the attribute values. In order to estimate the respondents' CS for improvements in rivers' environment over the *status quo*, different possible options were created, as presented in Table 6.17. It is reminded that the *status quo* is described as: river life is poor, water appearance shows no improvement, recreational activities are limited and river banks show signs of erosion.

Table 6.17: Scenario descriptions for CS calculations

	Scenario 1 High impact management	**Scenario 2** Medium impact management	**Scenario 3** Medium impact management	**Scenario 4** Medium impact management
River Life: fish, insects, plants	Good	Moderate	Moderate	Moderate
Water Appearance	A lot of improvement	A lot of improvement	Some improvement	Some 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

To find the CS associated with each of the above scenarios the difference between the welfare measures under the *status quo* and the reported management scenarios was calculated. It is noted that *status quo* effects were included in the calculations when they were significant and are interpreted as the utility of the SQ alternative following the considerable number of respondents who chose the No Change option especially in the Suir sample. As noted in Meyerhoff and Liebe (2009) if the SQ indicates a preference for the *status quo*, a strong *status quo* effect would lead to a negative WTP. On the other hand, ignoring the SQ would probably result in an overestimation of WTP. Bennett and Blamey (2001) argue that the inclusion of alternative specific policy labels and levels may redistribute the source of the utility in terms of the attribute marginal utilities and ASCs, while Johnston and Duke (2007) interpret the change they are valuing as marginal and drop the coefficient associated with the ASC from CS calculations.

Hoyos (2010) summarises relevant literature regarding the inclusion or omission of the SQ. The main findings are that in the context of unlabeled experiments including an ASC would violate the meaning of unlabeled, while applications excluding ASCs are abundant in the literature. At the same time, it has been argued that when excluding it the remainder of the model parameters would attempt to capture this effect, resulting in biased attribute parameter estimates. Hence, ASCs are important in order to interpret the preferences of the individuals and current state of the art in discrete choice analysis favour the use of an ASC for the *status quo* alternative, even if the attributes are generic.

The estimates of CS for the four scenarios are reported in Table 6.18. For comparisons, welfare estimates are calculated for both extended MNL and MMNL models, together with their 95% confidence intervals. Furthermore, a sensitivity analysis regarding the inclusion or not of the SQ is performed for the MMNL model. The CS calculations were based on models reported in Table 6.5 where the SQ was not significant in the case of the Boyne, while the opposite was true for the Suir since a considerable percentage of respondents (about 31%) opted for the SQ option. The variation reported in the CS estimates in Table 6.18 points to the strong influence the SQ effect has on WTP values in the present study and that including or excluding the *status quo* ASC can be decisive for welfare estimates.

Focusing on the MNL model, the higher CS value for the Boyne was observed under the second scenario due to the relatively higher magnitude of the River Life _M attribute compared to the Good (considered in Scenario 1). Results indicate that to maintain the utility level of the current situation, given the improvements in river quality, income adjustment equal to the CS is necessary. Regarding the Suir sample and the considerable percentage of those always choosing the SQ alternative hints at an SQ effect in this study. Hence, incorporating the ASC_{SQ} and considering the individual-specific variables, changes in river quality would result in negative utility indicated by CS values of -€6.53, -€14.93 and -€15.15. Although, the SQ was also included in the Boyne's CS calculation following the reported models' results, its effect was not that strong to influence CS figures like in the Suir.

Considering the best-fit MMNL model, findings show that the Boyne estimates of CS would result in positive utility. It is reminded that estimates correspond to a model that the SQ is not significant. On the other hand, regarding the Suir sample, results are sensitive to the inclusion/omission of the SQ. Hence, when the ASC_{SQ} is incorporated changes in river quality would result in negative utility. In contrast, when the ASC_{SQ} is omitted the CS figures would result in positive utility probably overestimating the WTP. It is also observed that the estimates of CS tend to be closest when the SQ is not included in the Suir's CS estimation. However, even in that case deviations are considerable since many of the implicit prices were larger in the Boyne than in the Suir.

Comparing results of positive utility from Table 6.18, for example, with the results from other studies that have been initiated from the implementation of the WFD it is observed that values are not that different. For example, Brouwer *et al.* (2010), although they did not follow the same approach of valuing components of river quality, report a CS for very good water quality in the whole Guadalquivir River basin of €169 to €257 per household per year with a mean WTP value of €212 per household per year. Furthermore, Hanley *et al.* (2006b) report welfare estimates for two rivers ranging from £57 per household to £128 for a number of policy scenarios, all designed to potentially improve river quality towards GES.

Although, it would be interesting to relate this study's values to average water costs the fact is that water charges in Ireland have been abolished. However, the Government in 2012 introduced a combined property and water levy of €100 per household per year which is applied independently of household size or income, while the scope is to introduce meter-based water charges for domestic users in 2013, in the context of a broad reform of the water services sector.

Table 6.18: CS (€ per household/year) (extended models) and sensitivity analysis for the Suir MMNL with and without SQ

	MNL[a,b]		MMNL[b]		
	Boyne	Suir	Boyne (without SQ)	Suir (with SQ)	Suir (without SQ)
Scenario 1	153.43 (101.35, 220.78)	-6.53 (-25.22,8.39)	181.16 (105.78, 277.71)	-43.77 (-87.54, 7.47)	61.80 (26.41, 97.07)
Scenario 2	165.83 (112.61,237.66)	13.98 (-2.55,27.82)	192.97 (120.36, 302.33)	-26.03 (-69.56, 22.10)	80.84 (42.00, 121.81)
Scenario 3	119.25 (73.16, 180.50)	-14.93 (-30.98,-0.74)	142.61 (79.42, 224.30)	-23.42 (-62.42, 17.20)	83.65 (41.35, 118.42)
Scenario 4	128.13 (81.28, 184.61)	-15.15 (-0.95,-31.76)	150.78 (85.84,239.72)	-43.64 (-82.20, -1.86)	62.89 (28.26, 96.71)

[a]SQ included in the estimation. [b]CS for the models described in Table 6.5.

Table 6.19 reports the results of comparing the magnitude of estimates for the different scenarios between catchments under the MNL and MMNL specifications. Not surprisingly the table shows that the null hypothesis of CS equality was roundly rejected for all four scenarios in the MNL and MMNL models when the SQ was included in the Suir's CS estimation. Finally, in three of the four scenarios in the MMNL model when the Suir's CS was estimated without the SQ the null hypothesis was also rejected at 1% significance level. As a result, the BT is not valid and in general it is not advisable considering this particular test.

Table 6.19: Testing equality of CS for each scenario (€ per household/year) (extended models)

	$CS_{Boyne\|MNL} = CS_{Suir\|MNL}$	$CS_{Boyne\|MMNL} = CS_{Suir\,(SQ)^{a}\|MMNL}$	$CS_{Boyne\|MMNL} = CS_{Suir\|MMNL}$
Scenario 1	0.000	0.000	0.002
Scenario 2	0.000	0.000	0.004
Scenario 3	0.000	0.002	0.058
Scenario 4	0.000	0.002	0.008

Notes: Prob. of H_0 equality reported. [a]Suir (SQ) is CS with the SQ included

Although, this study was not designed initially for BT application an attempt was made to explore how data performed in that context. In conclusion, the results from these hypotheses tests are somewhat inconclusive, although the weight of evidence is against the equivalence of value estimates. The results about the equality of models and implicit prices are important since they provide information about the structure of people's preferences, while the equality of estimates of CS is also important as this measure is used in CBA.

The tests of equality of CS estimates indicated that BT is not valid regardless of the omission or inclusion of the SQ. The different outcomes of the tests regarding BT validity is not an unusual phenomenon in the literature. Morrison and Bergland (2006) review studies regarding the validity of using choice modelling for BT and report results where parameter vectors are different and some of the implicit prices and surplus estimates are equivalent.

Information about the magnitude of errors likely to be experienced when using BT is provided in Table 6.20. TEs are calculated as defined in Subsection 6.4.1 using the model parameters of one catchment and the site attributes and individuals' characteristics of the other catchment (*i.e.*, by adjusting the value estimates as it was defined earlier: predicted WTP p (βs, Xp) = WTP p). These TEs for the MMNL models for a two-way comparison, *i.e.*, interchanging the study and policy site catchments, are shown in the last four columns of Table 6.20. Specifically, considering the columns seven and eight where the Boyne catchment is used as the study site and the Suir as the policy site, the reported TEs resulting from the MMNL ranged from 57% to 790%, depending on the scenario considered and the inclusion or omission of the $ASCS_Q$ in the Suir's CS calculation, demonstrating overall an "unacceptable range". Errors were only drastically reduced when the Suir catchment was used as the study site and the SQ was omitted, ranging from 38% to 64%. Finally, Table 6.20 also confirms that even when the differences between the CS absolute values are to be considered, these are smaller when ASC_{SQ} is omitted from the CS calculations of the Suir.

Following Colombo *et al.* (2007) a TE value of up to 30-80% may be considered acceptable for a CBA, particularly when the benefits clearly outweigh the costs. Ready and Navrud (2006) argued that the average TE for spatial value transfers both within and across countries tends to be in the range of 25% - 40%. Table 6.13 in Section 6.4.1 showed a wide range of TEs related to both value transfer and function transfer.

Regarding the latter, the maximum TE reported in the table was of 298% magnitude, while many studies reported TEs of less than 80%. Another review of BT studies of outdoor recreation found an average error of 80% (Smith and Pattanayak, 2002).

It should be noted that the validity of BT remains questionable in the academic arena since BT is subject to errors. The main sources, as mentioned previously in Section 6.4, are measurement errors that stem from the quality of primary data and generalization error in transfers which are related to factors such as the correspondence between sites and populations, the commensurability of non-market goods and policy contexts, and the BT methods applied (Rosenberger and Phipps, 2007). The validity of BT concerning both adjusted mean values and transfer of benefit functions is largely rejected in the studies of Bergland *et al.* (1995), Barton (2002) and Rozan (2004). On the other hand, findings of a TE of around 40% (Ready *et al.*, 2001) and of an average 28% in a meta-analysis model (Shrestha and Loomis, 2001) provide evidence of valid applicability. Furthermore, Luken *et al.* (1992) argued that if the process of transfer is able to give a broad indication of welfare benefits on the target site, this may still be informative for policy purposes, even if precise estimates cannot be obtained.

As mentioned previously, a further debate on the use of BT refers to whether adjusted mean transfers get closer to original site values compared to benefit functions. Barton (2002) is a supporter of unit transfers while on the other hand there are opponents of that view who declare to be in favour of function transfers (Desvousges *et al.*, 1998; Rosenberger and Stanley, 2006). However, as it was emphasised by Rosenberger and Johnston (2009) even if the preference is for function transfer there is no evidence in the literature to provide solid evidence on the type of function transfer that outperforms.

Table 6.20: Absolute value CS difference (€ per household/year) and TE (MMNL extended models)

	MMNL			Absolute value CS difference (€)[a]		Boyne *vs.* Suir[b]	Boyne *vs.* Suir	Suir *vs.* Boyne	Suir *vs.* Boyne
	Boyne (without SQ)	Suir (with SQ)	Suir (without SQ)	With SQ	Without SQ	With SQ	Without SQ	With SQ	Without SQ
Sc. 1	181.16 (105.78, 277.71)	-43.77 (-87.54, 7.47)	61.80 (26.41, 97.07)	224.93	119.36	780.67%	176.45%	123.13%	63.94%
Sc. 2	192.97 (120.36, 302.33)	-26.03 (-69.56, 22.10)	80.84 (42.00, 121.81)	219	112.13	789.70%	122.08%	111.95%	56.37%
Sc. 3	142.61 (79.42, 224.30)	-23.42 (-62.42, 17.20)	83.65 (41.35, 118.42)	153.51	46.44	660.24%	56.85%	113.63%	38.44%
Sc. 4	150.78 (85.84,239.72)	-43.64 (-82.20, -1.86)	62.89 (28.26, 96.71)	194.42	87.89	411.82%	116.37%	126.76%	55.64%

[a] $|CS_{Suir} - CS_{Boyne}|$, [b] $(|Pred.CS_{Suir} - CS_{Suir}| / CS_{Suir}) \times 100$

Finally, Brouwer and Bateman (2005a) suggest a methodology according to which value functions are iteratively built up from theoretical principles, rather than using statistically driven best-fit functions, with transfer errors being tested each time a new variable is added. Results show that when transferring between similar contexts, simple mean-value transfers outperform more complex value function transfers while this result is reversed when transfers are undertaken across dissimilar contexts. This finding is also confirmed in Bateman *et al.* (2011) putting again the emphasis on theoretical rather than ad-hoc statistical approaches when developing transferable value functions. Nevertheless, where the preferences of survey populations differ substantially from those at the policy site both approaches may well produce relatively large errors.

6.6 Analysis of the second set of choice cards

In order to analyse the data from the second set of choice cards that included the extra attribute Which River(s) are Improved with four levels (the Boyne, the Suir, Both, or None), interaction terms were created between this attribute and the river attributes. As a result, the utility function was specified in two alternative ways:

(i)

$$U = b^{*}ASC + b_{11}{}^{*}\text{River Life}_{\text{Boyne\_Good}} + b_{12}{}^{*}\text{River Life}_{\text{Boyne\_Moderate}} + b_{21}{}^{*}\text{River Life}_{\text{Suir\_Good}} + b_{22}{}^{*}\text{River Life}_{\text{Suir\_Moderate}}$$
$$+ b_{31}{}^{*}\text{Appearance}_{\text{Boyne\_A lot impr.}} + b_{32}{}^{*}\text{Appearance}_{\text{Boyne\_Some impr.}} + b_{41}{}^{*}\text{Appearance}_{\text{Suir\_A lot impr.}} + b_{42}{}^{*}\text{Appearance}_{\text{Suir\_Some impr.}}$$
$$+ b_{51}{}^{*}\text{Recreation}_{\text{Boyne\_A lot impr.}} + b_{52}{}^{*}\text{Recreation}_{\text{Boyne\_Some impr.}} + b_{61}{}^{*}\text{Recreation}_{\text{Suir\_A lot impr.}} + b_{62}{}^{*}\text{Recreation}_{\text{Suir\_Some impr.}}$$
$$+ b_{71}{}^{*}\text{River Banks}_{\text{Boyne\_no erosion}} + b_{81}{}^{*}\text{River Banks}_{\text{Suir\_no erosion}}$$

(ii)

$$U = b_{11}*\text{River Life}_{\text{Boyne\_Good}} + b_{12}*\text{River Life}_{\text{Boyne\_Moderate}} + b_{21}*\text{River Life}_{\text{Suir\_Good}} + b_{22}*\text{River Life}_{\text{Suir\_Moderate}} +$$
$$b_{31}*\text{River Life}_{\text{Both\_Good}} + b_{32}*\text{River Life}_{\text{Both\_Moderate}} + b_{41}*\text{Appearance}_{\text{Boyne\_A lot impr.}} + b_{42}*\text{Appearance}_{\text{Boyne\_Some impr.}} +$$
$$b_{51}*\text{Appearance}_{\text{Suir\_A lot impr.}} + b_{52}*\text{Appearance}_{\text{Suir\_Some impr.}} + b_{61}*\text{Appearance}_{\text{Both\_A lot impr.}} + b_{62}*\text{Appearance}_{\text{Both\_Some impr.}} +$$
$$b_{71}*\text{Recreation}_{\text{Boyne\_A lot impr.}} + b_{72}*\text{Recreation}_{\text{Boyne\_Some impr.}} + b_{81}*\text{Recreation}_{\text{Suir\_A lot impr.}} + b_{82}*\text{Recreation}_{\text{Suir\_Some impr.}} +$$
$$b_{91}*\text{Recreation}_{\text{Both\_A lot impr.}} + b_{92}*\text{Recreation}_{\text{Both\_Some impr.}} +$$
$$b_{101}*\text{River Banks}_{\text{Boyne\_no erosion}} + b_{111}*\text{River Banks}_{\text{Suir\_no erosion}} + b_{12}*\text{River Banks}_{\text{Both\_no erosion}}$$

The above specifications differ in that the first includes the ASC_{SQ} while the second does not. This is the case as a result of the restriction that the No Change level of the location attribute None of the Rivers is Improved should appear only in the No Change option for alternatives to make sense. Hence, when the ASC_{SQ} is included, levels related to improvements in both rivers should be omitted.

These specifications allow comparisons of preferences within the second set of cards but also between the second and the first four choice cards so as to see if preferences differ between the two sets. The analysis related to the second set of cards is presented in Appendix F. Findings for the Suir are also reported although it is acknowledged that the sample's weakness means it fails to provide any valuable contribution for an advanced analysis.

As a starting point of the analysis and in order to explore the sensitivity of the results to the inclusion/omission of the catchment/location attribute, Table F1 reports findings considering the second set of cards for both catchments under MNL and MMNL specifications, including all the involved attributes without interactions. Findings showed that in the case of the Boyne (MNL 1), Appearance and Recreation estimates were significant and positive, while River Banks, River Life _ G, as well as the catchment/location related estimates were all negative and significant. Fewer estimates revealed a significant sign in the Suir MNL 1 model. The models were also run without the additional attribute in order to explore whether it was causing the problem. However, as shown in the Boyne and the Suir MNL_2, results were not improved. Furthermore, although MMNL models revealed the existence of heterogeneity in the parameter, estimates did not alter the sign or significance of the mean estimates compared to MNL models.

Next, analysis focused only on the second set of cards and the hypothesis tested whether improvements are valued equally regardless of the involved catchment. Models with interactions between the catchment attribute and the river attributes were presented in Table F2 considering utility functions specified as in (i) and (ii) above. Furthermore, estimates concerning the local river could be compared across the two sets of cards in order to explore a framing effect. However, findings after running the second four cards using different model specifications did not seem to be reliable, providing many non-significant estimates of the wrong sign.

Then analysis focused on pooling all eight cards. Two approaches were considered. In the first approach the assumption was that all respondents have the same parameters with respect to the river where improvements took place. Hence, all eight cards were pooled together assuming that it did not matter for respondents where the improvements took place. Although, results, presented in Table F3, indicated the importance of parameter estimates, at least for the Boyne sample, this approach was abandoned as it did not allow comparisons between the two sets of choice cards especially since differences were anticipated.

The second approach adopted the specification of the dummy nested model in order to test the assumption that preferences regarding improvements were the same when a local river was valued on its own compared to it being valued along with another river. Hence, compared to previous specifications the objective here was to test if preferences changed between the first four and last four choice sets. In this case, instead of running two separate models for each set of choice cards only one model was run by interacting the attributes of the choice cards with a dummy that differentiates between the two sets. As Table F4 shows, especially for the Boyne, the model revealed significant improvements under both contexts (local river *vs.* local + another) however, it was noticed that not all attributes that were significant in the first four cards were significant in the second set. Nevertheless, for specific attributes the magnitude of estimates was higher in the case of improvements concerning both rivers. The Suir sample did not provide sensible results.

Table F5 presents results for the stacked data sets of the first four and the second four cards after omitting the location/catchment variable from the second set which was not common between the sets and adjusting for scale. Here, the equality of parameters after allowing for differences in variance was tested. Hence, the null hypothesis is that the preferences and the error variance do not differ between the two sets of choice cards. In the case of the MNL model for the Boyne, the LR test that model parameters differ only by a variance scale ratio is 140.760 and higher than the χ^2 of 18.3 value at the 5% level (with 10 d.f.). Hence, the hypothesis that the vector of parameters is equivalent across the two sets of choice cards should be rejected and the differences in scale parameter are not enough to account for the variations in the coefficients. This hypothesis was also rejected in the case of the MMNL specification (LR = 152.98 against a χ^2 of 27.6 value at the 5% level (with 17 d.f.). The estimated relative scale factor of less than one for the Boyne sample, implies that the variance of the error term or "noise" in the model based on the second set of cards with the location/catchment variable is bigger than in the base segment (local river). Hence, the data from the second segment has more random noise than the first segment that concerned the local river and probably indicates that respondents were more comfortable with the narrowly defined application focusing only on one river. A final attempt (Table F6) was made by pooling the data between the first four and the second four cards, but keeping from the second set of cards only choice sets that concerned improvements of the local river. The results showed as previously that an overall change in preferences for the attributes from the first to the second sequence was observed and furthermore, error variance was increased in the second sequence.

At this point it should be also stressed that different approaches were considered in order to include the second set of cards. In the first instance, it was thought to treat the second set of cards as a labeled CE. In this case, alternatives would be labeled as *status quo* (None of the rivers is improved), the Boyne, and the Suir. However, this idea was rejected as respondents seemed to bid for either their local river or the *status quo* providing no variability in the data. Furthermore, comparisons between the two sets were not straightforward following this line of analysis.

Another option was to ask respondents to answer one card concerning improvements in the Boyne and another concerning improvements solely in the Suir. In this context respondents would be asked to consider payments jointly, that is as if they were happening simultaneously. Again this scenario was rejected as respondents in the focus groups seemed to protest against the setting and chose almost exclusively their local river. In addition, this option increased the need for more choice cards and hence a bigger design which would have had as a consequence the increase of cognitive burden on respondents, the duration of the questionnaire and hence the cost of the survey.

Furthermore, another option that was considered was that of the split-sample approach. According to the research design in each catchment three independent samples were to be drawn. As a result, in each of the catchments one sample would value only the Boyne, another only the Suir and a third would value both the Boyne and the Suir. Choice cards in this latter sample were to be split in two sets, one concerning the Boyne and the other the Suir. However, this option was abandoned at an early stage due to budget constraints.

Further insight on how respondents treated the second set of cards was provided by the debriefing questions that followed the choice cards. Hence, in the Boyne sample when respondents who chose either Option A or Option B were asked to state if they ignored any of the attributes, the Which River(s) are Improved attribute did not report any significant difference percentage compared to environmental or Cost attributes. It is interesting though to note that the catchment attribute was ignored by 16% of respondents in the Boyne sample while only 1% ignored the attribute in the Suir sample. Finally, when respondents were asked to state which attribute came first in terms of importance when they were making up their mind 55% stated environmental improvements, 31% which river was improved and 14% the cost involved. The case of the Suir was a little different. According to responses to the same question, 46% of positive bidders made up their mind considering firstly which river should be improved, 31% considering primarily the environmental improvements and 23% their budget constrain.

6.7 Summary of main findings

Reported in this chapter were the preliminarily results from a survey of 504 respondents from the Irish adult population of two catchment areas (the Boyne and the Suir) designed to explore preferences and WTP estimates for four river attributes related to the implementation of the WFD in Ireland. The research design involved two samples from two distant HAs that should improve their river's environmental condition in order to achieve the objective of GES.

The chapter began with the presentation of a variety of different discrete choice model specifications. Particularly, two broad groups of models were considered. A basic model was employed where indirect utility was exclusively expressed in terms of the attributes, and SQ and an extended version was also used which considered socio-demographic and other interaction regressors of interest. Within each of these two groups three models were included. Hence, starting from the MNL the analysis proceeded to examine different discrete choice models that did not exhibit the IIA property, to demonstrate various other aspects. NMNL specification was firstly considered and then, a MMNL model specification was employed to further investigate, and account for, random taste variation among the respondents. Altogether for both discrete choice experiments 12 models were estimated to model responses.

A number of important findings were observed. Starting from the basic models specification it was clear that respondents between catchments did not share the same preference structure. In almost all the Boyne model specifications, all the river attributes and the Cost attribute were significant and of the expected sign. On the other hand for the Suir sample, significance of attributes, apart from the Cost attribute, was dependent on which model was applied. Another finding for the Suir sample was the significant and high SQ coefficient indicating that *ceteris paribus*, the *status quo* alternative was more desirable than Options A or B. Furthermore, for both samples and both basic and extended models the IV parameters for the two branches in the NMNL models were found to be statistically significantly different, which indicated two totally independent choice models for the two branches and hence evidence for the partition used in these models. A further robust finding was that all of the IV parameters were found to be within the 0-1 range necessary to be consistent with random utility theory. Examination of the standard deviation estimates of the random parameters in the MMNL models revealed that most of them were significant, indicating preference heterogeneity among the respondents.

As far as the extended models were concerned, they revealed that in both datasets, the inclusion of individual/household specific variables led to significant improvements in model performance across all classes of discrete choice models. Due to the high number of respondents refusing to reveal their income, little information was available regarding that variable. It should be noted that income is considered an important variable for demonstrating theoretical validity and reliability of the estimated models. This could cause some concern and an effort was made to account for this with other factors that could serve as proxies such as belonging to a certain occupation class (*i.e*, upper/middle class). Other social variables are included, such as being full-time employed and number of dependents in the household. LR-tests were used to assess improvements in model performance across the different discrete choice model specifications. In general, results from these tests highlighted that the NMNL models outperformed the basic MNL models, whereas the MMNL models were superior to both the basic MNL and NMNL models. Similar conclusions were derived using pseudo-R^2, BIC and the percentage of cases correctly predicted statistics.

Section 6.3 made use of different discrete choice model specifications in order to explore further respondents' preferences for river improvements focusing only on the Boyne sample. Two versions of the heteroskedastic and error components model along with an MMNL (triangular constrained distribution) revealed various relationships. Interesting findings were the existence of heterogeneity across respondents and choices, alternative specific variance heterogeneity (heteroskedasticity) in the unobserved effects of the No Change alternative but also the existence of heterogeneity in some of the parameter estimates. Unobserved preference heterogeneity was also explored by estimating a LCM with three segments. Segment membership coefficients revealed that specific individual characteristics increased or decreased the probability that the respondent belonged to a specific segment. It was found that 39% of the sample belonged to the first segment, 47% to the second, while 14% belonged to the third segment. It should be noted that this model provided the best fit among all models.

The last two sections focused on the application of the BT method between the two catchments. After offering a short overview of the different practices of the method and assessment of its validity, the tests employed in the context of this study were presented. These tests included comparisons in terms of models' coefficients, marginal WTP (implicit price) and CS estimates.

The equivalence of choice model parameters was the first test of interest. The LR-test of parameter equality (Swait and Louviere) revealed that differences in the scale parameter were not enough to account for the variations in the coefficients and therefore the choice models of the two catchments were different. This finding was consistent with both basic and extended versions of models and demonstrated that BT was not advisable. The second test dealt with the equality of implicit prices. The implicit WTP estimates were presented and contrasted across MNL and MMNL extended models. Confidence intervals were estimated using the Krinsky and Robb procedure with 1000 draws, whilst Poe, Severance-Lossin and Welsh test was employed for assessing the equality of means. Results showed that the implicit prices, when calculation was possible, for the considered attributes did not differ significantly between the two catchments in the MNL model. However, although all three implicit prices were equal in the MNL model, only Appearance _ S and Recreation were equal in the MMNL model. It is noteworthy that the inclusion of taste heterogeneity resulted in specific implicit prices differing between the two catchments under the MMNL specification. Hence, if this source of variation was ignored, it could lead to a misleading BT. Considering this test according to findings, results were more supportive of the use of implicit prices for BT.

The final test that was considered compared the CS estimates under four different scenarios. Findings showed that CS for the change from the *status quo* to the different scenarios increased in the case of the Boyne as improved river conditions in the catchments were considered. The greatest mean CS for the Boyne was not observed under the high impact management scenario due to the smaller coefficient of River Life _G compared to River Life _M. However, CS estimates for the case of the Suir were very sensitive to the inclusion/omission of the ASC_{SQ} indicating that ignoring the SQ would probably result in an overestimation of WTP. This is due to the fact that the utility attached to the SQ in the Suir sample was significant compared to the Boyne exhibiting also a coefficient of high magnitude. Comparing the magnitude of the estimates for the different scenarios between catchments, the results showed that the null hypothesis of CS equality was rejected regarding the considered scenarios and overall, BT was not advisable.

Furthermore, for each of the policy scenarios TEs were calculated for the MMNL model. Magnitudes of the TEs were very different depending on the scenario considered, the inclusion/omission of the ASC_{SQ} and on which catchment was used as a study site. The smallest range of TEs was observed when the Suir catchment was used as the study site and the SQ was omitted from the CS calculation, ranging from 38% to 64%. Overall, it can be concluded that different tests produced different results regarding the validity of BT but it seems that the weight of evidence is against the equivalence of value estimates in this particular study.

Finally, different approaches of analysing the data from the second set of cards were presented and results were reported in the relevant appendix without however revealing compelling findings. General notes are that there was evidence of change in the preferences for the attributes from the first to the second set of cards and that error variance was increased in the second set.

7

ANALYSIS OF CONTINGENT VALUATION MODELS

7.1 Introduction

The objective of this chapter is to analyse responses to the CVM question which was included as a follow-up question in the questionnaire of each HA along with the CE. The decision to include the PCCV question was justified by the fact that it allowed for the checking of consistency with CE responses, and comparison values of GES derived from each method and test, as well as comparison of the performance of both stated preference methods in a BT context.

The first section of this short chapter presents the way the CVM question was directed at respondents, the improvements on rivers' environment and the range of the employed payment bids. Then it describes the profile of respondents related to CVM responses by breaking down participants, as in previous chapters, to positive bidders, true zero bidders and protesters while it also presents the distribution of responses across the range of offered bids.

In Section 7.3, the different specifications that were employed in order to explore WTP responses and their determinants are presented along with the findings of each approach. Special focus was given to the presence of heteroskedasticity within data and importantly the treatment of protest response.

In Section 7.4, an attempt is made to see if estimated WTP values could be transferred between catchments. Both approaches to BT, transfer of unit values and benefit function, are outlined. Finally, a short overview of WTP values elicited from both valuation methods (CE and CVM) is reported. In the case of CE, the two main model specifications of MNL and MMNL are considered, while in the case of CVM mean WTP and estimated WTP from the selection model are reported. Finally, Section 7.5 summarizes the main findings of the chapter.

7.2 Profile of respondents to CVM for achieving GES

As presented in Chapter 2, CVM has been extensively employed to examine the benefits of improvements in rivers' and water environments. Although, there is an ongoing debate about the applicability and validity of the method and in particular about the different versions of elicitation mechanisms there is no consensus regarding the superiority of one version to the others. Langford *et al.* (1998) noted that as long as the bids are selected with care, and the sample size is not too small, there is no conclusive evidence that any alternative is superior to another. However, even the more widely accepted mechanism of Dichotomous Choice (DC) is not without its problems. In general, a dichotomous question format was not chosen due to the need for much larger sample sizes. Further issues associated with this method are its larger estimates, compared to open-ended questions, and that it is subject to some degree of 'yea-saying' or starting-point bias (Loomis 1990; Halvorsen and Sœlensminde, 1998; Kealy and Turner, 1993; Balistreri *et al.*, 2001). The option of an open–ended elicitation method was rejected, as it is well documented to be subject to various problems such as large non–response rates, protest rates, zero answers and outliers since it confronts individuals with an unfamiliar change that they have never thought about valuing before (Bateman *et al.*, 2002).

The CVM question was included as a follow-up question after the CE cards. In order to avoid question-answer fatigue it was decided to make use of a simple approach to the elicitation mode. Therefore, the PCCV method (Cameron and Huppert, 1989) was used according to which WTP responses are interpreted not as an exact statement of WTP but rather as an indication that the WTP lies somewhere between the chosen value and the next larger value above it on the payment card. This method was first developed by Mitchell and Carson (1981 and 1984) as an alternative to the bidding game. As the authors (Mitchell and Carson, 1989) noted, this approach does not require large samples compared to a referendum approach. However, although this method avoids the anchoring effects of DC since respondents select their own WTP amount (Ariely *et al.*, 2003) it is regarded that the chosen range of amounts can influence respondent's answers. For that reason, in this study respondents were encouraged to state any other amount from the range of the offered bids. The CVM question was directed at all respondents, protesters to previous choice cards or not.

The PCCV question was included in the questionnaire for different reasons. One of these reasons was to work as a consistency check. It can be used to check whether respondents were serious about their choices and whether they had understood the exercise since the improvements in the PCCV were described in such a manner that all attributes on the shown card attain their best level. This card represented a situation not described in any of the used CE cards, where not all attributes reached their best levels simultaneously on any one card. Furthermore, this approach offered the possibility to explore the issue of the 'packaging problem' (Jones 1997; Bateman *et al.*, 2002) by comparing elicited values between CE and PCCV for the same improvements as well as to investigate the method's potential in a BT context. Compared to CE it also gave the opportunity to individuals who objected to price range or method used to express their preferences.

Figure 7.1 shows how the hypothetical scenario was described with the river attributes of local rivers reaching their best potential. Respondents were asked to state the maximum amount they were willing to pay between the 25 points range of offered bids on an approximately logarithmic scale from 0 to 200, as presented in Figure 7.1., trying to avoid truncation bias caused by setting upper limits too low (Rowe *et al.*, 1996). Payments were set to occur each year for the next 10 years to improve the quality of the local river to the best conditions. The price range was based on the responses to the pilot study and focus groups using the open-ended elicitation format.

	No Change	Option A
River life: fish, insects, plants	Poor	Good
Water appearance	No improvement	A lot of improvement
Recreational activities	Walking Boating ~~Fishing~~ ~~Swimming~~	Walking Boating Fishing Swimming
Condition of river banks	Visible erosion that needs repairs	Natural looking banks
Annual household income tax	€0	€ **--------- per year** (for the next 10 years)

PAYMENT CARD				
€0	€10	€25	€50	€90
€1	€12	€30	€55	€100
€3	€15	€35	€60	€120
€5	€18	€40	€70	€150
€8	€20	€45	€80	€200
Other (please specify____________________________)				

WRITE IN (to the nearest EURO)......... | € | | | | |

Don't know

Figure 7.1: Payment Card Contingent Valuation (PCCV) format

Table 7.1 summarises the reaction of respondents to the task. A total of 140 (56%) and 96 (38%) individuals for the River Boyne and the River Suir respectively were willing to pay something for the improvements in their local river. However, 108 (43%) individuals in the Boyne catchment and 156 (62%) in the Suir catchment were not willing to pay even the lowest bid value of €1 presented to them on the payment card. Of these respondents 66 (26%) were identified as protesters in the Boyne and 81 (32%) in the Suir. As is illustrated, the Suir sample reported a higher frequency of zeros (two sample test of proportion found a significant difference with p-value = 0.00) than the Boyne, indicating that households in the Suir HA were more indifferent to the improvements than the WFD seeks to establish compared to the Boyne. The Suir sample exhibited a higher percentage of true zero bids than the Boyne. Furthermore, in the Boyne sample protesters were more than true zero bidders.

Table 7.1: Profile of respondents according to their reaction to CVM

	Survey sample respondents (%)		
	Boyne HA	Suir HA	Both HAs
Positive bids	140 (55%)	96 (38%)	236 (47%)
True zero bids	42 (17%)	75 (30%)	117 (23%)
Protesters	66 (26%)	81 (32%)	147 (29%)
"Don't know" answers	4 (2%)	-	4 (1%)
Total	**252**	**252**	**504**

Table 7.2 displays the distribution of responses in the survey across the bids for each HA. Prices as low as €1 and €3 gave respondents who might have found the suggested bids of choice tasks too expensive the chance to reveal their true value.

Table 7.2: Distribution of responses across the range of offered bids

	Survey sample respondents (%)		
WTP bids	Boyne HA	Suir HA	Both HAs
0	108 (43%)	156 (62%)	264 (52%)
3	-	1	1
5	6 (2%)	26 (10%)	32 (6 %)
10	17 (7%)	30 (12%)	47 (9%)
12	1	-	1
15	1	1	2
20	11 (4%)	11(4%)	22 (4%)
25	10 (4%)	3 (1%)	13 (3%)
30	5 (2%)	1	6 (1%)
40	14 (6%)	5 (2%)	19 (4%)
50	30 (12%)	6 (2%)	36 (7%)
55	1	-	1
60	9 (4%)	-	9 (2%)
80	7 (3%)	4 (2%)	11 (2%)
90	1	-	1
100	21 (8%)	8 (3%)	29 (6%)
120	4 (1%)	-	4 (1%)

200	2	-	2
Don't know	4 (2%)	-	4 (1%)
Total	**252**	**252**	**504**

Table 7.3 summarises responses reported in Table 7.2 after excluding protesters from the analysis in order to avoid downward bias, leaving a total number of usable responses of 186 for the Boyne and 171 for the Suir.

Table 7.3: Profile of respondents according to their reply to the PCCV question, excluding protesters

	Survey sample respondents		
	Boyne HA	Suir HA	Both HAs
Mean	38.34	13.99	26.68
St. deviation	38.71	24.99	35.00
Max-min	200-0	100-0	200-0
25th percentile	5	0	0
Median	30	5	10
75th percentile	50	10	50
90th percentile	100	50	90
95th percentile	100	80	100
99th percentile	200	100	120
Skewness	1.21	2.41	1.63
Kurtosis	4.83	8.02	5.90
Total	**186**	**171**	**357**

According to the results, 75% of respondents in the Suir sample had WTP values of €10 or less. For the Boyne, 75% of respondents had values of €50 or less. In addition, apart from the statistically significant difference between means (t = 6.993, p-value = 0.000), a positive value of the skewness statistic indicated the possibility of a positively skewed distribution. Furthermore, positive kurtosis indicated a relatively peaked distribution (too tall, that it is leptokurtic) especially for the Suir sample, as the graphs of Figure 7.2 show.

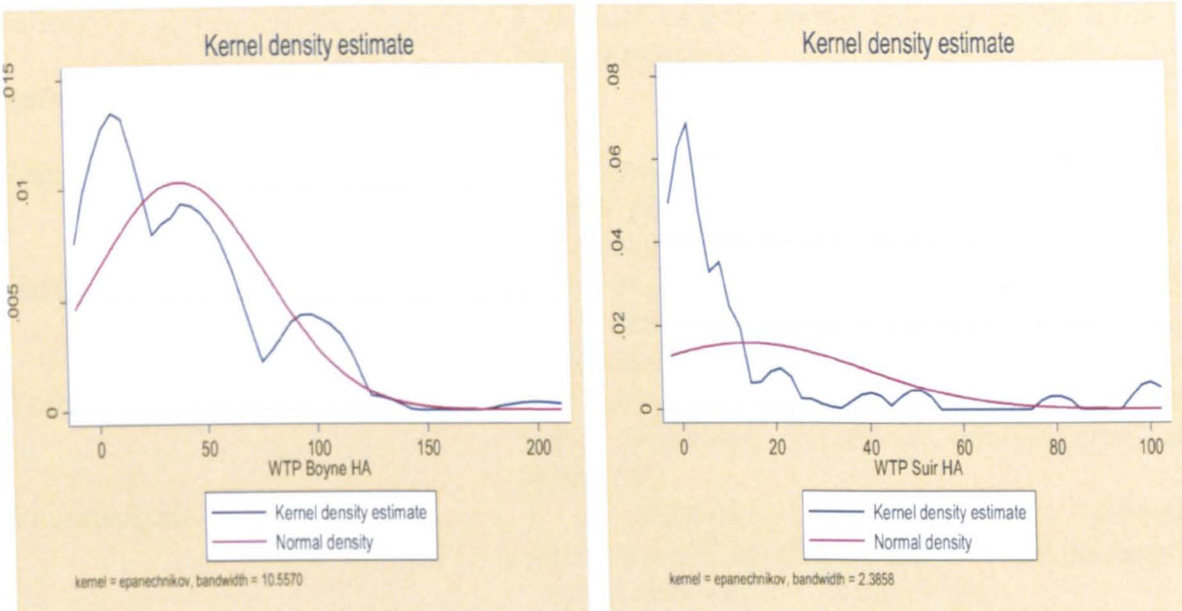

Figure 7.2: Kernel density estimate

7.3 Parametric analysis of PCCV responses

Table 7.4 presents the variables that were employed as determinants of PCCV responses, following a specification search that tested all relevant explanatory variables in the data, and their natural logarithms for significance. They included socio-economic, attitudinal, behavioural, knowledge related, and finally a variable of geographic reference.

Table 7.4: Variables included in analysis of PCCV responses

Variable name	Description
Socio-economic	
Age	Respondent's age scale 1 to 6, where 1=15 to 17 and 6=over 65
Hdegree	1 if respondent education is higher than secondary school, 0 otherwise
NoIncome	1 if respondent reported her income, 0 otherwise
Emful	1 if respondent is working full-time, 0 otherwise
Miclass [a]	1 if chief income earner belongs to the upper/middle class , 0 otherwise
Loclass	1 if chief income earner belongs to the low middle class , 0 otherwise

Farmer	1 if chief income earner belongs to the farmer class, 0 otherwise
Attitudinal/Behavioural/Knowledge	
Waterpol	1 if respondent is aware of any specific water related policy taking place in Ireland at the moment or in the past, 0 otherwise
Nscons	1 if respondent is not sure thinking of him/herself as being concerned about the environment, 0 otherwise
Yscons	1 if respondent is thinking of him/herself as being concerned about the environment, 0 otherwise
Vunsatisfqual	1 if respondent describes river's general environmental quality (water & surroundings) "very unsatisfactory", 0 otherwise
VisitLR	1 if respondent visits/has visited her local river, 0 otherwise
Location	
Distance	Continuous variable of distance in km from respondent's townland to the closest tributary

[a]Social classes were grouped as follows: upper middle class and middle class form the "Upper/middle class" category, lower middle class and skilled working class form the "Low middle class", other working class and those at lowest levels of subsistence form the "Low class" and large farmers + small farmers form the "Farmer" class.

Initially, the WTP value chosen by each individual was specified as a generalized Tobit model estimated via maximum likelihood procedures. In particular: $WTP = x\beta + \varepsilon$ where $\varepsilon \sim N(0, \sigma^2 I)$ where x represents socio-economic and other variables.

Following Daniels and Rospabe (2005) and Hynes and Hanley (2009), the *LL* function was adjusted to make provision for point, left censored, right censored and interval data. For individuals j that:

$j \in C$, WTP_j represents point data

$j \in L$, WTP_j represents left-censored

$j \in R$, WTP_j represents right-censored

$j \in I$, the unobserved WTP_j is at the interval $[WTP_{1j}, WTP_{2j}]$.

The *LL* is then given by:

$$\ln L = -\frac{1}{2}\sum_{j \in C} w_j \left\{ \left(\frac{WTPj - x\beta}{\sigma} \right) + \log 2\pi\sigma^2 \right\}$$
$$+\sum_{j \in L} w_j \log \Phi \left\{ \left(\frac{WTP_{Lj} - x\beta}{\sigma} \right) \right\}$$
$$+\sum_{j \in R} w_j \log \left\{ 1 - \Phi \left(\frac{WTP_{Rj} - x\beta}{\sigma} \right) \right\}$$
$$+\sum_{j \in I} w_j \log \left\{ \Phi \left(\frac{WTP_{2j} - x\beta}{\sigma} \right) - \Phi \left(\frac{WTP_{1j} - x\beta}{\sigma} \right) \right\}$$

where $\Phi\ ()$ is the standard cumulative normal and w_j is the weight of the jth individual.

It is worth remembering that the results of the parametric regressions reported in Table 7.5 were derived after omitting protesters from the estimation. In addition, checking for collinearity did not indicate any particular problems. The initial common Model 1 for the Boyne and the Suir was: WTP $= f$ (age, 3rd level education, upper/middle class, low middle class, farmer, concerned about the environment, not sure if concerned about the environment, distance in kilometres from the closest tributary, if respondent reported income, if aware of any water policy and if visits/have visited the local river). All variables were treated as dummies apart from age (1 to 7 categorical variable) and distance to the closest tributary. The latter was calculated with the use of GIS after collecting information on respondents' townland.

Following a more conservative approach, the models were run with Huber-White robust standard errors. The interval regression Models 1 predicting WTP for the Boyne and the Suir were statistically significant (χ^2 = 61.95 and 81.99 respectively, degrees of freedom = 11, $p < 0.000$). Hence, taken jointly the coefficients in the Generalized Tobit Interval model were significant. In addition, the McKelvey and Zavoina pseudo-R^2 was 0.20 indicating that the included predictors accounted for approximately 20% of the variability in the latent outcome variable for the Boyne and 42% for the Suir.

In the Boyne Model 1, results showed that respondents who were concerned about the environment, who were aware about the current or previous water policy in Ireland, had visited their local river and belonged to the low middle class and farmer class were more willing to pay for the river improvements representing GES. Results from the Suir (Model 1) showed that households belonging to the upper/middle and farmer class, having higher than secondary level education, being aware about the current or previous water policy in Ireland, and having visited their local river were more likely to favour the improvements. Surprisingly, distance seemed to have a positive impact on WTP. In this study both use and non-use values related to the river improvements are involved without however knowing which category dominates in respondents' preferences. With regard to the non-use values, there is no *a priori* expectation within standard economic theory for these values to decrease with distance. In addition, no availability of substitutes could be among the factors that contribute to a positive sign. Finally, a closer inspection revealed that removing the most distant respondents (more than 15 km distance) from the sample (9 respondents in the Boyne and 5 in the Suir) turned the variable insignificant in the Suir sample and negative and significant in the Boyne sample. It is noted that this result was held for all model specifications considered in this chapter.

Models 2 specification included variables such as education, upper/middle class, environmental concern, knowledge on water policy, and distance to, and familiarity with the local river in the specification of the conditional variance. These variables entered the variance specification collectively as multiplicative heteroskedasticity. As a result, $WTP = x \beta + \sigma (x) \varepsilon$, where $\sigma (.)$ represents an unknown 'scale' function of the explanatory regressors, and ε is a homoskedastic error term. The equation itself was specified as a Tobit model with multiplicative heteroskedasticity (Greene 2003). In the case of the Boyne compared to Model 1, the maximum likelihood estimate of NoIncome was negative and significant showing that respondents who refused to reveal their income were less likely to favour improvements. In addition, the estimate of farmer class was no longer significant. The variance equation in Boyne Model 2 shows that variables related to 3rd level education, environmental concern and knowledge on water policy had a positive and statistically significant effect on the variance of the regression, while belonging to the upper/middle class had the opposite effect. In the case of the Suir model, education, knowledge of water policy, visitation to the river and distance were significant variables in explaining heteroskedasticity. Furthermore, in explaining WTP for improvements, distance was no longer significant while compared to Model 1 additional variables explaining WTP were belonging to the Low middle class and being concerned about the environment.

Table 7.5: Interval regression of WTP for river improvements

	Model 1-Boyne		Model 1-Suir		Model 2-Boyne		Model 2-Suir	
Age	-1.574	(-0.72)	0.655	(0.75)	-0.565	(-0.27)	-0.214	(-0.54)
Hdegree	11.419	(1.20)	12.57	(1.66)*	11.216	(1.12)	10.350	(1.84)*
Miclass	13.628	(1.34)	34.97	(3.24)***	0.216	(0.03)	4.641	(1.03)
Loclass	16.969	(2.64)***	4.27	(1.41)	11.446	(1.81)*	5.091	(2.75)***
Farmer	25.985	(1.80)*	11.94	(2.33)**	8.23	(0.68)	6.242	(2.65)***
Yscons	21.761	(3.16)***	2.36	(0.98)	20.61	(3.39)***	4.356	(3.27)***
Nscons	-1.223	(-0.13)	4.38	(0.90)	-4.119	(-0.47)	6.507	(1.54)
Distance	-0.502	(-0.61)	1.49	(2.30)**	-0.168	(-0.20)	0.690	(1.20)
NoIncome	-13.445	(-1.56)	-2.81	(-0.81)	-11.640	(-1.68)*	-0.653	(-0.34)
Waterpol	23.459	(2.66)***	25.60	(2.03)**	25.470	(3.17)***	47.750	(4.35)***
VisitLR	15.974	(2.91)***	14.25	(3.95)***	12.721	(2.39)**	12.841	(4.55)***
Constant	10.633	(0.79)	-7.18	(-1.21)	13.087	(1.06)	-2.706	(-0.79)
Log of estimated Std. Err.	3.616	(50.73)***	3.007	(31.51)***				
Hdegree					0.526	(2.84)***	0.700	(3.05)***
Yscons					0.514	(3.05)***		
Waterpol					0.296	(2.46)**	0.701	(2.97)***
Miclass					-0.308	(-1.73)*		
VisitLR							0.881	(3.12)***
Distance							0.106	(5.63)***
Constant					2.990	(21.15)***	1.901	(7.44)***
<u>*Diagnostics:*</u>								
LL	-647.530		-608.677		-633.121		-555.899	
χ^2	61.95		81.99		92.81		79.24	
pseudo-R^2	0.204		0.417		NA		NA	
# of resp.	183		169		183		169	

Notes: z-ratio in parentheses (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%; Robust standard errors are used in the estimation.

It should be also noted that the homogeneity restriction for pooling the two samples was rejected since $\chi^2 = 2*(LL_{Boyne + Suir} - LL_{Pooled}) = 106.13$ against a critical value of 18.31 with 10 degrees of freedom. This test can be seen as the equivalent of a Chow test (Chow 1960) for linear regressions (Greene 2009).

Furthermore, in view of the number of protest responses a selection model was used. In order to test to what extent sample selection bias plays a significant role in the study a Full Information Maximum Likelihood (FIML) sample selection model was employed (Strazzera *et al.*, 2003). According to this model, respondents jointly decide on participation and valuation in the contingent market. At the same time, the Heckman (1979) two-step model to correct for the self-censoring of respondents and corresponding model specification error is also reported in Table 7.6. Stata 10 was used for their estimation. Brouwer and Martín-Ortega (2011) present an overview and empirical application of the suggested sample selection regression models.

Recoding protest voters to zeros, the selection models were estimated based on the respondent decision to either participate or protest[11]. In Table 7.6, a significant correlation in the WTP FIML models of both rivers is found, supporting the correction for sample selection and that estimates from FIML are preferred if there is significant correlation between the error terms of the participation and bid function. As noted also in Brouwer and Martín-Ortega (2011) censoring of protest voters is indefensible in this case, while the negative coefficient implies that removing protest response results in a downward effect on WTP. Similarly, the negative sign for λ suggests that not

[11] For the four respondents in Boyne who answered "don't know" in the CVM question a conservative approach was followed and responses were coded as no responses (Caudill and Groothuis, 2005) instead of dropping them from the sample.

Table 7.6: Estimated sample selection regression models

	Boyne Heckman 2-step model		Suir Heckman 2-step model		Boyne FIML 2-equation selection model		Suir FIML 2-equation selection model	
Selection model								
Hdegree	-0.031	(-0.13)	0.215	(0.83)	0.147	(0.60)	0.397	(1.62)
Emful	-0.019	(-0.12)	0.351	(2.32)**	-0.043	(-0.28)	0.098	(0.64)
Distance	0.062	(1.76)*	0.006	(0.35)	0.041	(1.28)	0.028	(1.69)*
Vunsatisfqual	0.875	(2.18)**	-0.231	(-0.60)	0.670	(1.67)*	-0.403	(-1.13)
Waterpol	0.280	(1.14)	0.121	(0.31)	0.465	(1.92)*	0.487	(1.38)
VisitLR	0.522	(3.50)***	0.281	(1.87)*	0.543	(3.78)***	0.388	(2.81)***
Bid model								
Constant	39.590	(3.83)***	34.735	(2.32)**	32.037	(4.47)***	15.301	(4.00)***
Miclass	18.698	(1.80)*	38.324	(3.78)***	19.595	(1.91)*	43.866	(5.97)***
Loclass	17.495	(2.46)**	3.794	(0.72)	17.311	(2.42)**	6.171	(1.54)
Farmer	23.796	(2.04)**	7.796	(1.06)	25.882	(2.24)**	11.157	(1.97)**
Diagnostics:								
λ	-35.574	(-2.15)**	-42.789	(-2.07)**	-20.036	(2.50)**	-15.803	(3.77)***
ρ					-0.500	(-2.90)**	-0.626	(-5.08)***
σ	44.514		42.789		40.065	(13.95)***	25.214	(12.12)***
χ^2	7.38*		15.06***		7.84**		36.65***	
LL					-1060.82		-922.92	
# of respondents	247		248		247		248	

Notes: z-ratio in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%

accounting for selection bias underestimates the probability of a positive WTP response.

Based on the results of FIML selection models, whether respondents had visited the river, previous knowledge of water policy and whether they think river quality is "very unsatisfactory", impact on the decision to participate (or protest). The same holds for distance variable which is only significant at the 10% level. Regarding respondent familiarity with the resource, it conforms to *a priori* theoretical expectations explaining participation (Brouwer and Martín-Ortega, 2011). The same is expected for belief and knowledge variables. In the bid model apart from the constant, social classes are used in the absence of reported income revealing significant positive coefficients. Compared to the Heckman two-step approach (Heckman 1979) the results are somewhat mixed. For example, in the Boyne model knowledge of water policy is not significant while significance of perception on quality increased. In the Suir sample, the full employment variable becomes significant while the visitation variable's significance level reduces.

Finally, it is common to estimate the PCCV equation by OLS where the dependent variable is either the final WTP or a 'log-linear' specification *ln (1+WTP)*. Results from OLS regressions are presented in Table 7.7 for completeness. Initially, the pattern of results in terms of significance and signs are not very different to those of the interval regressions reported in Table 7.5. However, it is interesting to note the negative and significant at 1% and 5% level of the NoIncome variable in the Boyne and the Suir log-linear models respectively, indicating that respondents who refused to reveal their income were willing to pay considerably less for river improvements.

Table 7.7: Linear and log-linear specifications of WTP for river improvements

	Boyne linear		Suir linear		Boyne log-linear		Suir log-linear	
Age	-1.416	(-0.69)	0.552	(0.66)	-0.044	(-0.43)	0.032	(0.47)
Hdegree	10.786	(1.20)	12.051	(1.64)	0.035	(0.11)	0.785	(2.02)**
Miclass	12.401	(1.27)	32.915	(3.17)***	0.834	(1.91)*	1.149	(2.37)**
Loclass	15.464	(2.54)**	3.987	(1.35)	0.902	(2.71)***	0.571	(2.52)**
Farmer	24.796	(1.78)*	11.319	(2.27)**	0.620	(1.16)	0.891	(2.78)***
Yscons	20.123	(3.09)***	1.675	(0.72)	0.950	(2.32)**	0.867	(4.97)***
Nscons	-0.578	(-0.06)	3.693	(0.80)	-0.758	(-1.12)	0.952	(1.74)*
Distance	-0.480	(-0.62)	1.425	(2.28)**	0.003	(0.15)	0.030	(0.99)
NoIncome	-12.498	(-1.51)	-2.780	(-0.82)	-0.934	(-2.86)***	-0.481	(-2.07)**
Waterpol	21.472	(2.57)**	23.723	(1.95)*	0.523	(1.53)	1.141	(2.00)**
VisitLR	14.340	(2.74)***	13.355	(3.82)***	0.949	(3.18)***	1.064	(4.71)***
Constant	9.797	(0.77)	-6.358	(-1.12)	1.444	(2.08)**	-0.193	(-0.43)
Diagnostics:								
F statistic	5.15		7.14		6.35		18.29	
R^2	0.206		0.412		0.226		0.350	
# of respondents	183		169		183		169	

Notes: t-stats in parentheses (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%. Robust standard errors are used in the estimation

7.4 WTP estimates for GES

In analyzing households WTP for river improvements, the value was calculated in three alternative ways: (i) using the average value of the stated (maximum) WTP in each sample (ii) using the linear regression model, and (iii) using the FIML selection model.

The results are presented in Table 7.8 and as shown, the FIML selection model produced average WTP values that were higher and statistically significant at 1% significance level than the average stated maximum WTP values in the sample, €47.73 *versus* €38.34 for the Boyne and €23.19 *versus* €13.99 for the Suir. The direction of magnitude remained the same even when the models that exclude inconsistent respondents were considered (Models 2). However, comparing WTP values (average and estimated) between Models 1 and 2, it was proved that the differences were statistically significant for the Boyne but not for the Suir models. From Table 7.8 it is also observed that the Boyne sample reported significantly higher WTP than the Suir in both specifications.

In addition, it is worth noting the statistically significant differences between the WTP estimates with and without sample selection. The selection based estimates are significantly higher than the non-selection based protest treatment procedure (linear regression model). Therefore, not accounting for selection bias results in a considerable underestimation of the WTP value. Similar results are also reported in Brouwer and Martín-Ortega (2011) where the authors assess the impact of the treatment procedure of protest votes on the estimated WTP welfare measure.

Table 7.8: CVM WTP estimates and CS differences

	Model 1- Boyne	Model 1- Suir	Absolute value CS difference (€)	Ha: diff != 0 Ha: diff > 0	Model 2- Boyne	Model 2- Suir	Ha: diff != 0 Ha: diff > 0
Max stated WTP[a]	38.34 (32.74, 43.94)	13.99 (10.22, 17.76)	24.35	t = 6.993 Pr(T > t) = 0.000	50.00 (42.85, 57.14)	13.93 (9.87, 18.00)	t = 9.082 Pr(T > t) = 0.000
# of observations	186	171			127	157	
Linear regression	37.96 (35.39, 40.52)	13.92 (11.48, 16.36)	24.04	t = 13.347 Pr(T > t) = 0.000	49.71 (46.16, 53.26)	13.85 (11.23, 16.48)	t = 16.418 Pr(T > t) = 0.000
# of observations	183	169			124	155	
FIML selection model	47.73 (46.50, 48.37)	23.19 (21.83, 24.54)	24.54	t = 28.991 Pr(T > t) = 0.000	58.72 (57.58, 59.86)	23.44 (22.00, 24.88)	t = 34.924 Pr(T > t) = 0.000
# of observations	252	252			159	238	

[a]Protesters are excluded

In terms of BT, it is obvious from Table 7.8 that a unit transfer of benefits, expressed as mean WTP per household per year, between the two sites would not be advisable for either version of WTP. Furthermore, since WTP differences are statistically significant so will the error measured as the difference between the CSs. In general, differences in WTP reported values may be due to various factors. For example, people at the policy site might be different from individuals at the study site in terms of socio-economic characteristics that affect their demand for improvements. In addition, substitute sites and activities might be different; there may be deviation in the magnitude of the change or at initial levels of environmental quality at the study and policy sites. In this study, differences on how respondents perceived the initial levels of environmental quality and the environmental quality of their river or the fact that the Suir catchment gathered more respondents in the lower social classes compared to the Boyne could be among the factors that might explain the deviation in estimates. Furthermore, more people in the Boyne rather than the Suir used their river for recreational activities and were more informed about water policies.

Since transferring the entire benefit function is conceptually more appealing than just transferring unit values as more information is taken into account, households′ WTP at the policy site was calculated using the estimates of the study site and multiplying them with the mean values of the policy site. Hence, as reported in Table 7.9, considering the Model 1 selection model, when the Boyne was the study site the calculated WTP for the Suir was €45.56, and when the Suir was the study site the calculated WTP for the Boyne was €21.45. Reported TEs in the table did not support the application of a BT between the sites at least when the Boyne was employed to "predict" the value of the

Suir (transfer asymmetry). In particular, calculated WTP values either underestimate or overestimate actual values.

Table 7.9: A comparison between calculated and actual WTP

	Calculated WTP		Actual WTP		TE[a]	
	Boyne	Suir	Boyne	Suir	Boyne[b]	Suir
WTP	€21.45	€45.56	€47.73	€23.19	55%	96%

[a]TE= $(|WTP_{\text{study site}} - WTP_{\text{policy site}}| / WTP_{\text{policy site}})*100$ [b]Boyne is the policy site

At this stage, it is possible to make comparisons of WTP for GES as these were derived by different elicitation methods and models in this study. Results are summarised in Table 7.10. Observing the findings, the concern that the estimation of WTP from multiple experiments using a subset of the attributes can lead to an overstatement of the total WTP for all of the improvements (the 'packaging effect') was verified as in previous studies (Foster and Mourato, 1999; Steer Davies Gleave, 2000). For example, in the Boyne sample when respondents were asked about their maximum WTP for the improvements to reach their maximum potential they stated a mean WTP of 48 €/hh/yr (Selection model, Model 1) in contrast to 123 and 114 €/hh/yr when improvements were valued individually. Differences of similar direction were observed for the Suir sample where the CVM elicited a value of €14 (max WTP model) *versus* €28 and €16 (MNL and MMNL specifications respectively). However, when the selection model was considered, mean WTP was higher than that reported under the CE MMNL model. Overall, evidence of double counting was present, demonstrating that values were sensitive to both valuation methods and also specifications used in a CE context. Finally, the CS values calculated in Chapter 6 for the GES are reported in the last two rows of the table. Cleary at least in the case of the Boyne, CE "inflates" CS values compared to PCCV where a holistic value is estimated. Results are mixed for the Suir as they are dependent on the inclusion or not of the SQ in the CS calculation.

Table 7.10: WTP and CS for GES by elicitation method

	Mean WTP and CS (€/hh/yr)	
Elicitation method/model	Boyne	Suir
PCCV max WTP	38.34[a] and 50.00[b]	13.99[a] and 13.93[b]
PCCV selection model	47.73[a] and 58.72[b]	23.19[a] and 23.44[b]
CE MNL model[c]	123.47	28.35
CE MMNL model[c]	114.66	16.27
CS - CE MNL model	153.43[d]	-6.53[d]
CS - CE MMNL model	181.16	-43.77[d] and 61.80[e]

[a]Derived from Models 1, [b]Derived from Models 2, [c]Positive and significant IPs are added to test the "packaging effect", [d]SQ included in the estimation. CS for the models described in Table 6.5.[e]SQ is not included in the estimation.

Considering the performance of the employed methods with regard to the transfer errors it is noted that, overall CVM provided errors of less magnitude (55% and 96%), while CE method revealed a high range of errors which was not only dependent on the selection of the policy/study site, but also on the inclusion of the SQ in the CS estimation (Suir model). As a result, transfer errors for the GES scenario varied between 64% and 780%. Finally, both methods revealed smaller transfer errors when the Boyne catchment was selected as the policy site.

7.5 Summary of main findings

This chapter examined responses to a CVM question which was included within the same survey in each catchment area. The CVM question used to elicit WTP for GES and the profile of respondents to this question were described. Results showed that the Suir sample demonstrated a higher number of zero and protest bids compared to the Boyne. In addition, protesters outnumbered true zero bidders at least in the Boyne sample. Distribution of responses revealed that 50% of respondents in the Suir sample had values of €5 or less, while the Boyne had values of €30 or less indicating once more how different samples were in terms of preferences for the same river improvements.

Different models were employed to analyse WTP bids. Findings showed that in general respondents, who for example were concerned about the environment, were more aware about water policy issues in Ireland and were familiar with their local river, were more willing to pay for river improvements corresponding to GES. More in-depth analysis also revealed heteroskedasticity in the data. Specifically, variables related to 3rd level education, environmental concern, knowledge on water policy, familiarity with the local river and distance had a positive and statistically significant effect on the variance of the regressions, while belonging to the upper/middle social class had the opposite effect. Furthermore, linear and log-linear specifications of WTP were also tested without however, revealing considerably different results than interval regression.

Sample selection models were employed in order to avoid removing protest response from the sample and a likely biased estimation of WTP. Respondent familiarity with the resource, being fully employed and finding river's quality unsatisfactory were among the factors that had a positive impact on participating rather than protesting. In Section 7.4, WTP values for river improvements were calculated using the average value of the stated (maximum) WTP, the linear regression and the FIML selection model. Results revealed that the selection model produced average WTP values that were higher than the average stated maximum WTP values for both Models 1 and 2 (non-consistent respondents were removed). In the same section, the potential of using the elicited values for BT was explored. A unit transfer was not advisable considering the statistically significant difference between WTP estimates. Furthermore, the benefit function approach did not demonstrate moderate TEs to make BT appealing.

Finally, the analysis of the CVM data offered the possibility to compare findings from both valuation methods (CVM and CE). As a result, the Boyne sample elicited values of between €47.73 and €58.72 for the GES when the PCCV regression model was used and of €181.16 when the MMNL discrete model was used for the analysis of choice data. Hence, CS was considerably higher than the PCCV WTP elicited values. Results were mixed in the case of the Suir sample in which CE (MMNL specification) resulted in positive or negative utility dependent on the inclusion/omission of the SQ in the CS calculation. Considering CS with the inclusion of the SQ due to considerable *status quo* effects, the value of €61.80 is higher than that of €23 of the PCCV (regression model).

8

MODELLING CHOICE INCORPORATING PHYSCHOMETRIC VARIABLES AND DISCONTINUOUS PREFERENCES

8.1 Introduction

The focus of this chapter is on exploring the impact of psychometric variables, which were measured by follow-up questions based on choices made by respondents in the CEs. As shown in Chapter 6, extended models that included socio-economic and psychometric variables performed better than those without. However, although it is common for researchers to measure and include socio-economic variables in their analysis in order to account for individual heterogeneity, issues related to respondent's cognitive ability or a variety of concerns other than utility maximization such as "who else is paying?" or "what my friends/family would like me to chose" are not frequently considered. In this chapter, more emphasis is placed on the category of psychometric variables and different model specifications are employed for their analysis.

Section 8.2 starts with a short literature review on how cognitive psychology and information theory have provided tools for exploring issues related to decision-making processes. Then the chapter proceeds (Subsection 8.2.1) to investigate through different model specifications the impact of cognitive burden on choice. Emphasis is placed on this issue as it is regarded that respondents in a CE are faced with a quite complex task which is dependent on different factors (*e.g.*, number and levels of the attributes, complexity of their definition, *etc.*). Respondents' cognition is calculated according to self-reported assessment of individual's ability to concentrate on the choice task, remember all the necessary information, think clearly and logically, and choose the best option. Hence, testing is realised through the prism of perceived cognitive burden. In addition, an attempt is made to explore the impact of the inclusion of the cognitive variable on BT.

It is regarded that future research should concentrate more on behavioural theory in order to investigate how respondents come up with their choices, adopting a broader concept than that of *Homo economicus*. In this survey by including follow-up questions, an attempt is made to investigate heterogeneity in the rules that underlie choices. Hence, respondents were asked to choose between true or false in a series of statements, as presented in Tables 5.19 and 5.20 of Chapter 5, describing various considerations that might have impacted their decision-making. In addition, two of these statements attempted to verify if respondents paid attention to specific aspects of the valuation scenario. Subsection 8.2.2 deals with heterogeneity in the information process and the rules that underlie choices and their effect on choice.

Finally, in the context of this chapter existence of discontinuous preferences is explored in Section 8.3 by using responses to a question that attempted to retrieve information regarding unwillingness to trade off gains and losses. This data is incorporated in different ways in MMNL specifications and comparisons are allowed. The chapter finishes with Section 8.4, which summarises the main findings of the analysis.

8.2 Cognitive process and other considerations in decision-making

Heterogeneity that is related to respondent's cognitive ability as well as heterogeneity in the rules that underlie choices are issues of concern that have preoccupied researches who have employed stated preference methods. As the following short review demonstrates, different approaches have been used in the framework of environmental valuation in order to explore cognitive process and capture unorthodox to utility maximisation decision rules.

For example, Frör (2008) developed a technique to detect and analyze the bounds of rationality inherent in WTP statements in CVM surveys which was based on cognitive psychology. The results showed that individual differences in information processing play a major role in the validity of CVM responses and hence respondents' different information processing modes should be considered in these studies. More particularly, the author included in his survey two types of questions (Frör 2008, pp.573-4):

1: *How true are the following statements regarding your personal attitude?*

2: *When you think about your decision whether and how much to contribute to the proposed project, are the following statements true?*

Frör's (2008) question 1 was developed to measure general cognitive dispositions in CVM interviews and respondents were asked to rate statements on a 5-point likert scale ranging from 1 (not true at all) to 5 (completely true). Such statements were of the type: "Thinking hard and for a long time about something bores me", "I enjoy doing something that challenges my thinking abilities like for example playing chess", "I believe in trusting my hunches", and "I generally prefer to accept things as they are rather than to question them".

Frör's (2009) question 2 was used for measuring the extent of heuristic information processing and respondents were asked simply whether the presented statements applied to them or not. Some of the statements used to represent a number of important aspects of possible heuristic decision-making were: "I made my decision based on my first feeling about this program right after it was presented to me", "All aspects were equally important for my decision", "There are so many aspects in this project but only a few of them were really relevant for my decision", and "Even if I had had more time available for thinking about this program I don't think that my decision of how much to contribute to it would have been different".

Schkade and Payne (1994) in their efforts to investigate the process of economic thought employed another technique from psychology, called verbal protocols, in order to explore what a respondent is thinking when answering a WTP question in a CVM framework for the preservation of migratory waterfowl. The technique they used is borrowed from cognitive psychology and is a 'think aloud' analysis of respondent's decision-making. Hence, after asking the respondent to state her/his maximum annual household WTP in an open-ended context, the following questions were asked that required her/him to report everything that went through her/his mind. In particular, the questions were (Schkade and Payne, 1994, p.93):

1. *How did you come up with your dollar amount in the previous question?*
2. *How difficult was it for you to come up with a dollar amount?*
3. *How confident are you that the amount you stated is the right amount for your household?*
4. *How many other important environmental issues would you agree to support with a similar dollar amount each year?*

The main findings of this study were that a variety of considerations affected respondents' WTP including an obligation to pay a fair share of the cost for the solution and a concern for a larger set of environmental issues. Further findings coincided with research on the psychology of decision-making that demonstrates that individuals construct their values at the time they are asked rather than reporting a well-defined value.

Tackling the issues of information and cognition in relation to valuing environmental benefits, Hutchinson *et al.* (1995) emphasized three major problems when valuing complex goods in the framework of CVM. These were the level of knowledge of the respondent, the problem of respondent comprehension and cognition, and the problem of embedding, nesting, and sequencing effects. As the authors stress, focus groups interviews, and debriefing of respondents in the survey design and piloting stages are all important tools in assessing respondents' familiarity and level of knowledge.

In order to ameliorate problems of a cognitive nature, techniques such as that of verbal protocols that encourage respondents to think aloud while completing the questionnaire and verbal probing that asks respondents about the strategies they employ in answering questions can be borrowed from cognitive psychology. As a result, Hutchinson *et al.* (1995) made use of both probes and protocols in their study of afforestation. The use of protocols in the pilot version of the survey helped to improve the context of the market and to convey the levels of provision in a significant, realistic, and achievable manner. Talk aloud protocols assured that respondents were aware of the significance between the levels of the good and the bid. The section where written probes were used had the aim of exploring the effect of specifically provided information and respondents' reasons for given answers.

Another issue that can undermine the validity and reliability of the resulting estimates is the presence of embedding effects. As the authors suggested, in order to avoid this effect the differences in provision levels must be regarded as significant, realistic and achievable and the survey instrument should be well-designed with very careful framing of the transaction. In addition, respondents could be asked to indicate what percentage of their offer was just for the stated benefit as a final control method.

Vatn (2004) stressed the need to improve choice theory by using observations made in valuation studies. He also emphasised that deviations from economic theory, when not the result of poorly designed surveys, could be a result of the fact that researchers underestimate or neglect the effect of the social sphere in shaping both information and preferences. According to the author, "what is lacking is an understanding of how individuals relate to each other and how social processes help the individual to act reasonably – should I dare say- rationally" (Vatn 2004, p.14). In this frame, information and preferences are also social. Individuals utilise choice rules for 'similar' situations when faced with choices involving great information needs. Prices inform preferences and price bids may be taken to convey information on good's quality. Finally, preferences are neither complete nor continuous and are ordered relative to the *status quo*. Hence, following Vatn focusing on the social dimension of preference construction is a way to add new insight to the theory of choice which should not imply necessarily an individualist rationality.

Spash *et al.* (2009) tried to extend the standard economic approach to valuation by including psychological and philosophical factors in their CVM study of biodiversity improvements. In particular, ethical questions were employed to measure the level of belief in species protection extending from animal rights to economic and human centred questions. The vehicle to achieve that was to ask respondents to choose the statement that best matched their opinion about the scheme to get hydro-power companies to release more water to the rivers to mimic a natural flow in order to provide habitat for endangered wildlife species. A "Can't answer-this is too complicated" choice was also offered. Planned behaviour was measured in terms of attitudes, subjective norms and perception of control over the situation. An example of measurement of attitudes in Spash *et al.* (2009, pp.263-4) is set out below. Thirteen paired type questions were included. These included:

1a. *Paying more for electricity to restore biodiversity will increase the diversity and abundance of plant and animal species in the Tummel area (extremely likely to extremely unlikely).*

1b. *Increasing the diversity and abundance of plant and animal species in the Tummel area is: (extremely bad to extremely good).*

The following is one of the six paired format questions used to measure subjective norms:

1a. *My spouse/partner would think that I (should to should not) pay more for electricity to preserve biodiversity in the Tummel area.*
1b. *Generally speaking, how much do you want to do what your spouse/partner thinks you should do? (very much to not at all).*

Finally, perceived behavioural control was measured by asking respondents to state how much they agree or disagree, for example "paying more for electricity" or "trusting electricity companies for improving biodiversity". In the same framework, respondents were asked to state how much control they believe they have "over selecting electricity supplier" or "over ensuring that the collected money will go into improving biodiversity". These were single questions of a 7 point scale. The results showed that factors of social psychology and philosophy may offer a better understanding of motives behind responses to CVM questions compared to socio-economic variables.

Accordingly, Fischer and Hanley (2007) tried to explore and assess information management and decision behaviour in the framework of a CVM for hedgerows' conservation by adopting an economic-psychological approach. The mixed technique approach included: (i) an audio protocol, (ii) a behaviour observation during the interview, and (iii) a questionnaire.

More specifically, the first technique had as its primary objective to measure the time participants spent on their decisions. Hence, recording started as soon as the WTP question was posed, and stopped after the respondents had stated their bids or after they had given their reasons for not being willing to contribute to the programme. The second technique involved the observation of the respondents by the interviewer and the recording of the former's emotional involvement and perceived time pressure in the interview situation on a -3 to +3 scale. The final technique concerned the completion of a questionnaire that aimed to explore individual's emotional involvement on the topic, individual's knowledge about the topic, attitude towards the proposed finance mode, environmental awareness, and several socio-economic variables. Furthermore, the presence or absence of cue words was investigated by an experimental approach that compared a control group with a standard valuation scenario and an experimental group with the one that included the cues. Overall, the results were in favour of the validity of CVM and showed that respondents in this framework do have the ability to make preference-based choices. However, depending on situational variables, a substantial proportion of respondents did not express preferences for the good through WTP. Situational determinants included the perceived pressure of time, perceived complexity of the valuation task, perceived risk, perceived responsibility, and verbal cues in the valuation scenario.

Another issue that is related to cognitive difficulty is that of certainty, which is less explored in the framework of CE relative to CVM surveys. Lundhede *et al.* (2008) recorded the post-decisional stated uncertainty in CE studies where respondents were asked to report their perceived certainty regarding their choice following each choice set. In particular, the employed question was asking respondents how certain they were about their choice using a 5-point likert scale.

The objective was to explore the influence that within-choice-set utility differences across alternatives might have on respondents' self-reported certainty level. Other survey design factors were also considered. The authors firstly estimated a mixed logit model based on respondents' choices without taking into account the stated uncertainty. Then they estimated an indirect utility function which was utilized to assign an aggregate utility measure to each alternative in the choice sets. In this way, they constructed a measure of utility difference. In addition, they estimated a probit model to explain the self-reported certainty level. The utility difference variable created in the first step was included among other determinants. Finally, in the third step, they evaluated the effect of recoding respondent choices in two different ways: uncertain choices were either (i) eliminated from the sample, recoded as a *status quo* choice, or (ii) re-coded by using the results of step one as a choice of the best alternative if different from the one chosen. The findings of this study suggested that respondent's uncertainty is also a relevant issue in CEs and that at least a significant part of the expressed uncertainty has perfectly rational reasons. Specifically, the authors argued that respondent's certainty is driven by utility differences between alternatives and that uncertainty is affected by issues such as the number of choice sets, income level, and gender.

Finally, Swait and Adamowicz (2001) attempted to capture through modelling, by using a latent class choice model, decision-making approaches across a sample of respondents in a given CE, as a function of complexity and cumulative cognitive burden. The authors obtained these measures by turning to information theory which provided a measure of information content or uncertainty (entropy) inherent in a decision context such as a CE situation. Entropy was simultaneously a function of the number of alternatives, the number of attributes, the relationship (correlation) between the attribute vectors themselves, and the structure of preferences. This measure was then incorporated into a latent class discrete choice econometric model along with other factors that were hypothesized to affect preference structure and/or strategy selection. Findings showed that within an experimental choice task, the model reflected changing aggregate preferences as choice complexity changed, and as the task progressed.

8.2.1 Heterogeneity in the cognitive ability of individuals in the Boyne catchment and variable's impact on BT

Table 8.1 presents the parametric models that were considered in order to explore the impact of the cognitive ability variable. It should be noted that the analysis focused on the Boyne catchment considering the weaknesses of the Suir sample. Models 1 and 3 present the MNL and MMNL models without the cognition related variable and are reported as baseline models. All MMNL models were estimated assuming normal distribution for the parameters, Halton sequences and 150 replications. The variable of cognitive ability is introduced in Models 2 and 4. Results showed heterogeneity in the ability of respondents to perform in the context of an experimental choice task. The variable was negative and significant (Models 2 and 4) meaning that the higher the score (that is the easier the task) the less likely it was for the respondent to choose the *status quo*. This result coincides with similar findings in the literature showing that increasing complexity or difficulty may produce more non-choice or adherence to the *status quo* (Dhar 1997a, 1997b; Meyerhoff and Liebe, 2009). Results also show that adding the new interaction brought changes to the model and explained more heterogeneity. The MMNL model with the cognitive ability variable had a higher fit and increased the significance of the coefficients. Next, Model 5 (HEV) implied that there is some unobserved variable whose values vary between alternatives. The model specification allowed variances to vary across utilities and with other variables; in this case the cognitive ability. Results showed that heterogeneity was observed across respondents and choices.

Model 6 included only respondents that did not differentiate in terms of difficulty between the two sets of choice cards. Comparing results between this model and Model 4, differences were observed in the significance of some of the coefficients which decreased. Overall, from the findings shown in the table it is interesting to find evidence of the argument that cognitive ability has a role to play in a CE context. In particular, findings show that it has an impact on respondents' preferences and preference heterogeneity.

Table 8.1: Models including/omitting cognitive ability (Boyne)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	MNL	MNL	MMNL	MMNL	HEV	MMNL
River Life _G	0.748 (3.734)***	0.733 (3.649)***	1.386 (2.888)***	1.353 (3.165)***	0.782 (2.488)**	1.291 (2.954)***
River Life _M	0.973 (5.750)***	0.955 (5.543)***	2.007 (3.147)***	1.761 (5.174)***	0.839 (2.803)***	1.721 (4.992)**
Appearance _A	0.960 (5.122)***	0.987 (5.217)***	1.809 (2.743)***	1.647 (3.845)***	0.706 (2.741)***	1.149 (2.496)**
Appearance _S	0.641 (3.756)***	0.650 (3.788)***	0.619 (1.516)	0.625 (1.591)	0.577 (2.369)**	0.746 (1.781)*
Recreation _A	0.448 (2.647)***	0.478 (2.797)***	1.188 (1.420)	1.020 (2.151)**	0.142 (0.766)	0.505 (1.044)
Recreation _S	0.287 (2.053)**	0.287(2.040)**	0.191 (0.524)	0.079 (0.245)	-0.005 (-0.029)	0.002 (0.007)
River Banks	0.717 (5.833)***	0.725 (5.804)***	1.513 (2.318)**	1.249 (3.395)***	0.484 (2.845)***	1.065 (2.588)***
Cost	-0.026 (-7.599)***	-0.024 (-6.878)***	-0.056 (-3.162)***	-0.047 (-5.421)***	-0.024 (-2.893)***	-0.047 (-4.724)***
SQ	0.892 (0.131)	1.521 (1.866)*	-1.428 (-0.898)	1.448 (0.940)	-0.830 (-0.666)	3.325 (1.530)
GenderSQ	-0.606 (-2.578)***	-0.599 (-2.461)**	-1.077 (-1.882)*	-1.146 (-2.154)**	-0.844 (-1.741)*	-0.924 (-1.452)
AgeSQ	0.138 (1.500)	0.084 (0.954)	0.292 (1.300)	0.182 (0.934)	0.128 (0.903)	0.169 (0.691)
HdegreeSQ	0.154 (0.569)	0.399 (1.390)	0.508 (0.834)	0.982 (1.565)	0.301 (0.802)	1.530 (2.269)**
DepntSQ	-0.174 (-1.622)	-0.186 (-1.700)*	-0.273 (-1.056)	-0.204 (-0.975)	-0.216 (-1.053)	-0.047 (-0.176)
FullemplSQ	-1.172 (-4.673)***	-1.235 (-4.829)***	-1.881 (-3.293)***	-2.006 (-3.555)***	-1.418 (-2.061)**	-2.709 (-3.766)***
MiddleclSQ	0.971 (2.603)***	0.923(2.453)**	1.521 (1.886)*	1.778 (2.515)**	1.174 (1.739)*	-0.348 (-0.373)
DistanceSQ	0.105 (4.485)***	0.105 (3.960)***	0.256 (2.289)**	0.218 (3.397)***	0.103 (1.741)*	0.305 (3.643)***
WaterpolicySQ	-2.494 (-3.858)***	-2.392 (-3.739)***	-2.695 (-2.563)**	-2.639 (-2.651)***	-2.640 (-2.275)**	-3.095 (-2.175)**
NsconsernedSQ	3.045 (5.654)***	2.961 (5.352)***	6.180 (2.654)***	5.223 (3.766)***	3.546 (2.163)**	4.286 (1.712)*
UnsatisfqualSQ	-1.140 (-4.109)***	-1.071 (-3.772)***	-2.256 (-2.785)***	-1.623 (-2.854)***	-1.407 (-1.671)*	-2.328 (-3.068)***
InstinctSQ	0.696 (2.870)***	0.748 (2.930)***	1.784 (2.311)**	1.698 (3.024)***	0.547 (1.248)	0.719 (1.100)
SocialconSQ	0.635 (2.792)***	0.674 (2.887)***	1.291 (2.035)**	1.423 (2.422)**	0.818 (1.637)	0.694 (1.159)
CognitiveSQ		-0.060 (-2.651)**		-0.135 (-2.772)***		-0.197 (-2.743)***
<u>*Het. in scales (cogn. ability):*</u>					0.027 (2.451)**	
<u>*Scale par.:*</u>						
No Change					0.379 (2.479)**	

Change A					0.530 (3.404)***	
Change B					1.000 (fixed)	
St. Deviations						
River Life _G			2.042 (1.482)	1.579 (2.335)**		0.151 (0.186)
River Life _M			2.079 (1.630)	1.344 (2.924)***		0.887 (1.848)*
Appearance _A			1.740 (1.875)*	1.098 (1.731)*		1.107 (2.373)**
Appearance _S			2.471 (4.434)***	2.507 (5.168)***		1.814 (3.610)***
Recreation _A			2.291 (1.438)	1.749 (2.541)**		1.732 (2.824)***
Recreation _S			2.041 (1.782)*	1.702 (3.201)***		1.259 (2.934)***
River Banks			3.167 (3.308)***	3.069 (5.822)***		2.439 (5.128)***
Diagnostics:						
LL	-692.29	-678.69	-629.86	-616.65	-677.08	-401.04
χ^2	355.04	387.96	612.29	612.36	491.49	437.15
Pseudo-R^2	0.204	0.219	0.327	0.331	0.266	0.352
BIC	748.53	737.50	704.91	694.18	741.24	472.79
Correctly predicted	51%	51%	49%	50%	51%	52%
Observations	852	840	852	840	840	564
# of respondents	213	210	213	210	210	141

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%..

As noted in previous chapters, and particularly in Chapter 3, the variance of the error term can differ over factors such as geographic regions, data sets, and time, *etc.* Swait and Louviere (1993) described the variety of reasons under which variances may differ over observations. Focusing on psychological factors rather than the traditional concept of variance regarding unobserved factors, Bradley and Daly (1994) allowed the scale parameter to vary over stated preference experiments in order to allow for respondents' fatigue, while Ben–Akiva and Morikawa (1990) allowed the scale parameter to differ between respondents' stated intentions versus their actual market choices. What is also attempted in this subsection is an exploration of whether scale parameters between Models 7 and 8, shown in Table 8.2, varied as a result of different cognitive ability among respondents. The scale parameter (Swait-Louviere) test was performed in BIOGEME Version 1.7 and Joint Model 9 was estimated with 500 Halton draws.

Model 8 omits the respondents that found the tasks relatively difficult (scored less than the mean value of the variable after omitting protesters, which is less than 20.71), while Model 7 is run by omitting those that found the tasks relatively easy (scored 20.71 or above in the likert scale). What is firstly observed is that the models differ in the number of significant parameters of river improvements as well as in heterogeneity in their means. Model 7, regarding the sample of respondents facing higher cognitive burden, reported more significant parameters compared to Model 8. However, the latter model reported an increased significance of the coefficients.

In order to test the hypothesis of identical preferences after adjusting for scale, the LR-test for the nested models was conducted, normalising the set of respondents who found the task relatively difficult.

Table 8.2: Further models regarding cognitive ability (Boyne)

	Model 7	Model 8	Model 9
	MMNL	MMNL	MMNL Joint
River Life _G	4.714 (2.425)**	1.220 (1.482)	1.73 (2.24)**
River Life _M	3.790 (2.352)**	2.955 (4.068)***	2.78 (3.93)***
Appearance _A	6.854 (2.369)**	1.627 (2.998)***	2.67 (3.60)***
Appearance _S	4.334 (2.330)**	0.620 (1.230)	0.934 (1.67)*
Recreation _A	-0.918 (-0.778)	2.478 (2.518)**	1.50 (2.25)**
Recreation _S	-1.621 (-1.658)*	1.010 (1.818)*	0.450 (1.05)
River Banks	7.925 (2.374)**	1.409 (2.781)***	2.39 (3.58)***
Cost	-0.112 (-2.675)***	-0.046 (-3.530)***	-0.069 (-4.40)***
St. Deviations			
River Life _G	8.718 (2.164)**	3.234 (2.715)***	4.00 (2.83)***
River Life _M	3.493 (1.804)*	2.417 (3.256)***	2.65 (3.14)***
Appearance _A	9.205 (2.629)**	0.530 (0.475)	3.57 (3.49)***
Appearance _S	14.235 (2.390)**	2.281 (2.673)***	4.30 (3.31)***
Recreation _A	3.110 (1.717)*	3.133 (2.087)**	3.41 (2.12)**
Recreation _S	7.940 (2.272)**	2.446 (3.061)***	2.48 (2.82)***
River Banks	14.188 (2.558)**	2.375 (3.518)***	4.68 (3.99)***
Diagnostics:			
LL	-337.62	-298.66	-680.09
χ^2 /LL ratio test	361.84	272.77	546.997
Pseudo-R^2	0.348	0.313	0.287
BIC	373.40	333.12	720.44
Scale			Scale: 0.771, t-test: 0.91, p-value: 0.36, Rob.t-test: 0.66, Rob. P-value:0.51
Observations	472	396	868
# of respondents	118	99	217

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%.

The LR-test value of 87.62 against a critical χ^2 value of 26.29 at the 5% level (with 16 d.f.) showed that the hypothesis of identical preferences across the two samples was rejected even after rescaling. Hence, there is evidence that respondents with less or more cognitive burden value river improvements differently. Finally, the reported scale parameter associated with the subset of respondents who found the task relatively easy was not significantly different to the scale parameter associated with the subsets of respondents who faced more difficulties. It should be noted that when heterogeneity over preferences regarding the price attribute was allowed, the models by stacking the two datasets did not converge, so this attribute was restricted to be fixed. Preferences towards the other attributes were assumed to be normally distributed.

Furthermore, literature provides empirical evidence of the validity of environmental BT by expanding the analysis to include control factors such as differences in respondent attitudes (Brouwer and Spaninks, 1999) which have not been accounted for in previous studies. Stepwise inclusion of sets of explanatory variables based on theory and data availability is also presented by Brouwer and Bateman (2005a, 2005b) and Bateman *et al.* (2011), where the authors provide guidance on the appropriate specification of transferable value functions across countries in the context of the WFD. In this framework, an attempt is made here to relate the inclusion of the cognitive variable to its impact on BT and perform a sensitivity analysis. Results are presented in Table 8.3 where the CS from a full model (Model 4 of Table 8.1), as estimated in Chapter 6, and the CS from a model estimated after the omission of the cognition related variable (Model 3 of Table 8.1) were calculated. Both MNL and MMNL specifications were considered.

The table shows that overall, omitting the cognitive ability variable reduced the size of the reported CS. However, the equality of CS was not rejected for all scenarios under the MNL specification. On the other hand, regarding the MMNL in three out of four scenarios, equality was rejected at the 10% significance level. Therefore, there is evidence of the impact of perceived cognition on reported CS and subsequently on the performance of BT.

Table 8.3: CS and TEs with and without cognition related variable (€ per household/year) (Boyne)

	MNL		MMNL			$CS_{full\ model} = CS_{without\ cognitive\ var.}$		*Mean value transfer error*[a]	
	Full model	Without cognitive var.	Full model	Without cognitive var. Boyne	Without cognitive var. Suir[c]	MNL	MMNL	Full model[b]	Without cognitive var.
Sc. 1	153.43 (101.35, 220.78)	137.65 (97.69, 190.40)	181.16 (105.78, 277.71)	98.60 (56.25, 177.84)	64.08 (20.47, 105.54)	0.347	0.053	193.13%	53.87%
Sc. 2	165.83 (112.61,237.66)	148.40 (103.37, 211.01)	192.97 (120.36, 302.33)	110.15 (66.06, 183.34)	81.76 (43.01,117.95)	0.339	0.053	138.70%	34.72%
Sc. 3	119.25 (73.16, 180.50)	107.88 (74.73, 154.31)	142.61 (79.42, 224.30)	61.60 (29.91, 122.26)	77.48 (39.92, 115.67)	0.368	0.032	70.48%	20.49%
Sc. 4	128.13 (81.28, 184.61)	116.53 (84.03, 156.91)	150.78 (85.84,239.72)	89.22 (49.20, 171.02)	57.75 (21.62, 98.05)	0.369	0.075	139.75%	54.49%

[a] $(|CS_{study\ site} - CS_{policy\ site}|/CS_{policy\ site})*100\%$, where Boyne is defined as the study site and Suir as the policy site. [b]Calculations are based on estimates reported in Table 6.18 for Suir without SQ. [c]CS calculated without SQ.

Furthermore, an attempt was made to explore this impact in terms of the reported mean value TE between the two specifications. The last two columns of Table 8.3 show that transfer errors decreased dramatically in all scenarios when the CS was calculated from the model which omitted the cognitive ability variable. However, it should be reminded that for the Suir's CS estimation the SQ was omitted. Table 8.4 presents the relevant models regarding the Suir sample.

Table 8.4: Models including/omitting cognitive ability (Suir)

	MMNL Model 1	MMNL Model 2
River Life _G	-0.833 (-0.897)	-0.532 (-0.498)
River Life _M	1.976 (1.920)*	1.947 (2.140)**
Appearance _A	2.329 (2.543)**	2.816 (2.745)***
Appearance _S	1.660 (1.758)*	1.202 (1.465)
Recreation _A	1.908 (1.853)*	1.705 (1.666)*
Recreation _S	1.135 (1.911)*	1.291 (2.138)**
River Banks	-1.207 (-1.845)*	-1.113 (-1.508)
Cost	-0.149 (-3.707)***	-0.140 (-4.615)***
SQ	15.980 (2.634)***	11.602 (3.527)***
GenderSQ	-1.675 (-1.966)*	-1.783 (-2.159)**
AgeSQ	-0.994 (-2.218)**	-0.876 (-2.417)**
HdegreeSQ	-2.548 (-2.540)**	-2.449 (-2.620)***
DepntSQ	-1.322 (-2.372)**	-1.044 (-2.752)***
FullemplSQ	4.197 (2.386)**	3.475 (2.793)***
MiddleclSQ	-6.930 (-2.413)**	-6.531 (-2.829)***
DistanceSQ	-0.128 (-1.316)	-0.122 (-1.385)
WaterpolicySQ	-5.045 (-2.891)***	-4.235 (-2.579)***
NsconsernedSQ	14.921 (2.330)**	12.617 (2.781)***
UnsatisfqualSQ	-4.349 (-2.909)***	-3.998 (-2.988)***
InstinctSQ	5.316 (2.579)***	5.062 (3.019)***
SocialconSQ	-0.345 (-0.411)	-0.828 (-1.061)
CognitiveSQ	-0.163 (-1.279)	
St. Deviations		
River Life _G	5.661 (3.433)***	5.531 (3.763)***
River Life _M	7.738 (3.693)***	7.248 (4.540)***
Appearance _A	5.213 (2.745)***	4.380 (2.837)***
Appearance _S	1.782 (1.762)*	2.854 (2.027)**
Recreation _A	3.757 (2.970)***	3.289 (3.601)***
Recreation _S	0.566 (0.782)	0.089 (0.110)
River Banks	4.410 (3.253)***	3.983 (3.947)***
Diagnostics:		

LL	-392.53	-394.66
χ^2	603.56	608.10
Pseudo-R^2	0.434	0.435
BIC	465.93	465.62
Scale	56%	56%
Observations	632	636
# of respondents	158	159

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%.

At this point, considering the importance of "building" up the models, it is worthwhile mentioning the impact of including contextual variables in a BT context and the importance of the availability of secondary data about non-standard information. Regarding contextual variables, it is argued that while their inclusion may improve the degree to which a value function explains values at the study site, in a function transfer framework they can generate error to the extent that this assumption does not hold for the policy site (Bateman *et al.*, 2011). The authors argue that when it is not straightforward to determine whether sites are similar or dissimilar an examination of secondary source data regarding the characteristics of sites and their surrounding populations can help such an assessment. Furthermore, in the case of heterogeneous sites where a function transfer is employed, availability of secondary data could have an important role in restricting the specification of models to those variables available from these data which economic theory has clear expectations (Bateman *et al.*, 2011). In this framework, it may be preferred to opt for more generic functions specified to only include generic drivers of utility highlighted by economic theory rather than transferring ad-hoc and possibly over-parameterised, statistical best-fit functions which may incorporate contextual variables.

8.2.2 Heterogeneity in information process and rules that underlie choices

The next table (Table 8.5) focuses on the Boyne sample and presents MMNL models (of 150 Halton draws with normal distributed parameters) that considered other psychometric related variables and their impact on choice. In particular, Model 1 presents the extended version of the model without considering the psychometric variables, "I only trusted my hunches" and, "I made a choice thinking what my family and friends would expect me to choose". It is noted that other relevant variables such as respondents who considered their budget constraints and believed that improvements will happen close to their residence or who where "thinking rationally", were also considered but did not preserve their significance when building up the extended version of the model.

Adding the instinct related variable in Model 2 and the variable of "social concern" in Model 3 it was observed that respondents who made a choice based on what their family and friends would expect them to choose and those who trusted their instinct were more likely to opt for the *status quo* option. Furthermore, the addition of these two variables seemed to improve the model (LR = 16.04 compared to a critical χ^2 value of 5.99 at the 5% level with 2 d.f.). Model 5 was estimated solely with these "rational" individuals who answered true the question, "I chose the option that I thought was right given the improvements, the rivers involved and my available income".

Table 8.5: Models regarding psychometric related variables

	Model 1	Model 2	Model 3	Model 4	Model 5
	MMNL	MMNL	MMNL	MMNL	MMNL
River Life _G	1.187 (2.825)***	1.292 (3.065)***	1.222 (2.964)***	1.353 (3.165)***	0.759 (1.295)
River Life _M	1.767 (4.923)***	1.810 (5.054)***	1.706 (5.051)***	1.761 (5.174)***	2.173 (3.579)***
Appearance _A	1.880 (3.915)***	1.766 (3.891)***	1.761 (3.919)***	1.647 (3.845)***	2.490 (2.901)***
Appearance _S	0.699 (1.786)*	0.658 (1.706) *	0.663 (1.709)*	0.625 (1.591)	1.164 (1.983)**
Recreation _A	1.179 (2.380)**	1.083 (2.254)**	1.103 (2.365)**	1.020 (2.151)**	1.411 (2.088)**
Recreation _S	0.270 (0.804)	0.201 (0.614)	0.164 (0.504)	0.079 (0.245)	0.261 (0.573)
River Banks	1.428 (3.653)***	1.383 (3.552)***	1.284 (3.435)***	1.249 (3.395)***	2.263 (2.865)***
Cost	-0.045(-5.197)***	-0.048 (-5.338)***	-0.044 (-5.303)***	-0.047 (-5.421)***	-0.058 (-3.186)***
SQ	3.253 (2.013)**	2.024 (1.192)	2.352 (1.509)	1.448 (0.940)	3.016 (1.533)
GenderSQ	-1.190 (-2.203)**	-1.132 (-2.048)**	-1.204 (-2.330)**	-1.146 (-2.154)**	-0.801 (-1.160)
AgeSQ	0.194 (0.917)	0.210 (0.935)	0.205 (0.977)	0.182 (0.934)	0.127 (0.492)
HdegreeSQ	0.936 (1.492)	1.185 (1.767)*	0.879 (1.431)	0.982 (1.565)	1.374 (1.482)
DepntSQ	-0.283 (-1.224)	-0.185 (-0.808)	-0.261 (-1.186)	-0.204 (-0.975)	-0.309 (-1.049)
FullemplSQ	-2.244 (-3.828)***	-2.353 (-3.773)***	-2.041 (-3.635)***	-2.006 (-3.555)***	-1.578 (-2.110)**
MiddleclSQ	1.395 (1.855)*	1.759 (2.238) **	1.360 (1.927)*	1.778 (2.515)**	1.576 (1.807)*
DistanceSQ	0.209 (3.254)***	0.250 (3.560)***	0.181 (2.927)***	0.218 (3.397)***	0.245 (2.716)***
WaterpolicySQ	-2.672 (-2.536)**	-2.751 (-2.726)***	-2.629 (-2.511)**	-2.639 (-2.651)***	-2.576 (-2.189)**
NsconsernedSQ	4.714 (3.429)***	5.247 (3.632)***	4.826 (3.603)***	5.223 (3.766)***	4.297 (1.891)*
UnsatisfqualSQ	-1.481 (-2.448)**	-1.660 (-2.721)***	-1.450 (-2.541)**	-1.623 (-2.854)***	-0.540 (-0.668)
InstinctSQ		1.799 (2.916)***		1.698 (3.024)***	
SocialconSQ			1.334 (2.424)**	1.423 (2.422)**	
CognitiveSQ	-0.131 (-2.593)***	-0.134 (-2.618)***	-0.127 (-2.650)***	-0.135 (-2.772)***	-0.167 (-2.252)**
St. Dev. of parameters					

River Life _G	1.302 (2.065)**	1.389 (2.375)**	1.438 (2.042)**	1.579 (2.335)**	1.524 (1.537)
River Life _M	1.424 (3.036)***	1.385 (2.913)***	1.330 (2.978)***	1.344 (2.924)***	1.723 (2.878)***
Appearance _A	1.893 (4.238)***	1.695 (3.649)***	1.462 (3.196)***	1.098 (1.731)*	3.228 (2.883)***
Appearance _S	2.523 (4.275)***	2.496 (4.729)***	2.447 (4.538)***	2.507 (5.168)***	3.727 (3.206)***
Recreation _A	1.861 (1.936)*	1.966 (2.459)**	1.640 (1.903)*	1.749 (2.541)**	3.511 (2.606)***
Recreation _S	1.745 (3.458)***	1.640 (3.326)***	1.753 (3.314)***	1.702 (3.201)***	2.366 (2.753)***
River Banks	3.002 (6.158)***	2.989 (6.188)***	3.001 (6.066)***	3.069 (5.822)***	3.814 (3.631)***
Diagnostics:					
LL	-624.67	-619.78	-621.63	-616.65	-523.51
χ^2	596.32	606.09	602.40	612.36	508. 60
Pseudo-R^2	0.323	0.328	0.326	0.331	0.326
BIC	696.85	694.63	696.48	694.18	593.38
Correctly predicted	49%	50%	50%	50%	49%
Observations	840	840	840	840	708
# of respondents	210	210	210	210	177

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%. Model 1: "social concern" and "instinct" variables omitted, Model 2: "instinct" variable added, Model 3: "social concern" variable added, Model 4: both psychometric variables added, Model 5: with "rationally behaving" respondents

Compared to Model 1 the mean parameter of River Life _G and its standard deviation were no longer significant, as well as the SQ parameter, the gender and the unsatisfied about river's quality variable. Furthermore, a small increase was observed in the standard deviation of half of the parameters compared to Model 1, demonstrating higher heterogeneity around the mean.

Next, an attempt was made to perform a sensitivity analysis regarding the impact of such psychometric variables on estimated CS. Results are presented in Table 8.6, where the CS from a full model (Model 4 of previous Table 8.5) and the CS from a model estimated after the omission of the two psychometric related variables (Model 1 of Table 8.5) were calculated. In addition, CS was also estimated in the case where only socio-economic variables were considered. Therefore, water policy, environmental consciousness, finding river's environmental quality unsatisfactory and the last three psychometric variables were omitted.

The table shows that overall, omitting these variables reduced the size of the reported CS. However, the equality of CS was not rejected for all scenarios. On the other hand, regarding the CS of the restricted model which included only the socio-economic variables reduced considerably the size of the CS and differences were statistically significant at the 5% and 10% significance level. As a result, Table 8.6 shows evidence of the impact of attitudinal, knowledge, psychometric, and other related variables on the reported CS, and subsequently on the performance of BT. It is anticipated that in this study a more generic function with variables about which we have clear, prior expectations developed from theoretical rather than ad-hoc statistical approaches

(Bateman *et al.*, 2011) is likely to produce smaller TEs and is deemed more appropriate considering also dissimilarities across the sites.

Table 8.6: Sensitivity of CS to the omission of psychometric variables

	Full model	Without psychometric vars	Only with socio-economic vars	$CS_{full\ model} = CS_{without\ psychometric\ vars}$	$CS_{full\ model} = CS_{with\ socio\text{-}econ\ vars}$
Sc. 1	181.16 (105.78, 277.71)	158.91 (85.14, 254.76)	101.24 (41.27,172.44)	0.349	0.064
Sc. 2	192.97 (120.36, 302.33)	172.03 (101.94, 270.32)	122.51 (58.29, 203.14)	0.369	0.103
Sc.3	142.61 (79.42, 224.30)	112.42 (50.06, 191.84)	60.31 (5.64, 121.51)	0.267	0.032
Sc.4	150.78 (85.84,239.72)	118.92 (54.23, 200.54)	73.82 (21.63,133.69)	0.264	0.045

8.3 Heterogeneity in the attention individuals paid to attributes (discontinuous preferences)

It is regarded that a result of the cognitive process of decision-making is the use of heuristic rules that are proximate drivers of most human behaviour that stem from some weakness to fully account cost and benefits (McFadden 2000). Blamey *et al.* (1997) noted that trying to find the precise strategies employed by respondents enhances our general understanding of the psychology of response formulation, with a view to designing questionnaires in a way that maximises reliability and validity. In their report, the authors presented some of the strategies respondents might be expected to use when endeavouring to identify their preferred option within each choice card in a CE setting. Characteristically, they noted that the strategies people use to process information can also be viewed within a cognitive cost-benefit framework.

More particularly, the authors firstly cited the optimizing strategy that is based on the additive utility model according to which the individual adds within each alternative the utility(s) from each attribute and computes its overall utility, and then compares the available alternatives. Another strategy is that of the additive-difference model where the decision-maker first compares each alternative on each attribute prior to reaching an aggregate evaluation. There is also the ideal-point model whereby decision-makers are assumed to have a vision of the perfect alternative, while according to the base-reference model, decision-makers evaluate alternatives in terms of the differences or deviations from a base or No Change alternative. However, different individuals may have different ideas about what constitutes the *status quo* (No Change) and that is where bias may occur.

The lexicographic model, that has attracted researchers' interest, adopts a rule of decision-making that is believed to be related to cognition ability with regard to dealing with task complexity in a CE setting. Hence, the respondent first considers the relative importance of the attributes. The most important attribute is then selected and the alternative performing best on this attribute is selected irrespective of the levels of the other attributes.

Considering the framework of CEs, it is argued that they impose a significant cognitive burden on respondents which can compromise choice consistency (Sælensminde 2001). As such, it is likely that in complex situations respondents will adopt simplified decision rules (DeShazo and Fermo, 2002). Other cases that may explain lexicographic behaviour is when there is a correlation among the attributes, if respondents consider that an attribute is of relatively high importance (Luce *et al.*, 2000; Blamey *et al.*, 2002) or when respondents adopt an attribute as a form of protest vote (Spash and Hanley, 1995).

Campbell *et al.* (2006) argued that although respondents may have a ranking of the attributes when they make up their mind, their choice is based solely on the level of their most important attribute(s). Hence, they always choose the alternative that is best or worst with respect to a specific attribute, or subset of alternatives. As a result, lexicographic preferences violate the continuity axiom and according to the authors, ignoring these decision-making heuristics introduces systemic errors and leads to biased point estimates. In order to identify if lexicographic preferences were present in their survey the authors made use of a follow-up question to assess whether or not respondents adopted such a decision-making rule. In particular, the employed question asked respondents whether in making their choices they considered all of the characteristics equally.

The "Yes" or "No" option was offered and those who said no were asked to specify the characteristic or characteristics that they took most into account. Responses indicated that the expected annual Cost attribute was the attribute least attended in the discrete CE. Campbell *et al.* (2006) investigated the sensitivity of individual-specific WTP estimates conditional on whether lexicographic decision-making rules were accounted for by using a mixed logit specification.

According to Sælensminde (2006), lexicographic choices may be a result of (i) study designs where differences between the alternatives are too great, and (ii) simplification of the choice task as a consequence of respondents' differing abilities to choose, rather than the result of lexicographic preferences. He also noted that it is difficult to determine if the lexicographic approach of the respondent is due to (i) or (ii), but nevertheless 'problematic choices' need to be handled as they can have an impact on the implied valuation. Another point was that the share of 'apparent' or 'natural' lexicographic choices was reduced when respondents were given more choices in a sequence.

In testing lexicographic choices, Sælensminde (2006) only considered whether the respondent had consistently chosen the alternative with the best level, for example the lowest price, for one of the attributes included in the task. That revealed that price was the most common 'sorting attribute' among modes of transport. Furthermore, the author by using an OECV question after the completion of the CE tasks showed that lexicographic choices in his study were at least partly a result of the respondents' real preferences. In this context, the OECV data were used as an indication of the basis for lexicographic choices in the stated choice data. In particular, respondents who had chosen lexicographically with price as the 'sorting attribute' between journey alternatives had done so based on their real preferences, since the valuation from the OECV data was lower for this group than for the group that had not chosen lexicographically. So, if the lexicographic choices are due to actual preferences, one would expect consistency between stated choice and CVM valuations. However, the author noted that this result can hardly be generalised as "the share of lexicographic choices caused by simplification will probably increase with the number of attributes in the task and if respondents have less *a priori* knowledge of the attributes" (2006, p.338). Another important finding of this study was that a logistic regression of lexicographic choices on socio-economic variables revealed that the education variable was significant and negative while the difficulty to concentrate variable was significant and positive when the survey contained only four choice sets. As a result, the simplification hypothesis was reinforced and the applicability of CE was questioned if for example only highly educated people were able to choose in a compensatory manner.

The 'elimination by aspects' approach involves a sequential narrowing down process in which individuals typically start with what they perceive to be the most important attribute, and eliminate all alternatives that do not reach a satisfactory level on this attribute (Blamey *et al.,* 1997). The process then continues for the second most important attribute, and then the third, fourth and so on until a single alternative remains. Finally, causal heuristic and strategic behaviour are the last two approaches cited in Blamey *et al.* (1997). Causal models and schemas are commonly used to explain or predict outcomes in which individuals may attempt to influence provision of attributes, options or level of payment by adopting a strategic behaviour. Apart from the above mentioned strategies in choice making, Payne (1976) argued that individuals may not use strategies that accord entirely with any one model but rather combinations of strategies (Payne, 1976; Klayman, 1985; Mazzotta and Opaluch, 1995) that tend to involve a sequential use.

Closing this short literature review on heuristics, McFadden (2000) highlighted that, although human behaviour may be governed by rules, underlying encoded preferences exist and should direct economists to look through the 'smoke-screen' of rules in order to retrieve the preferences needed to value economic policies. In order to face this challenge it seems valuable for economists to work together with other scientists from other relevant disciplines.

In this study, in trying to explore the issue of discontinuous preferences respondents who chose Option A or Option B were asked straight after the choice cards to say if the statements presented in Table 8.7 were true or false. Results from these debriefing questions show that a high percentage of respondents in both samples did not ignore many of the river attributes while 82-83% considered the Cost attribute in their choice making. In the case of the Boyne sample, it seems that the River Life attribute was the most important to respondents while the Suir sample demonstrated a slightly more consistent behaviour of not ignoring river attributes compared to the Boyne sample. However, when individuals were asked if they considered all attributes equally, 71% of the Boyne sample said yes *versus* 62% of the Suir sample. This difference was statistically significant at 10% level ($z = 1.4806$, $Pr(Z > z) = 0.069$). As a result, a number of respondents revealed some type of discontinuous preferences.

Table 8.7: Profile of respondents according to the importance of attributes

	Survey sample respondents (%)								
	Boyne HA			Suir HA			Both HAs		
	True	False	N/S	True	False	N/S	True	False	N/S
I ignored the river life characteristic	17 (9%)	175 (90%)	2	3 (3%)	78 (93%)	3	20 (7%)	253 (91%)	5
I ignored the water appearance characteristic	23 (12%)	169 (87%)	2	2 (2%)	79 (94%)	3	25 (9%)	248 (89%)	5
I ignored the recreational activities characteristic	23 (12%)	168 (87%)	3	1	79 (94%)	4	24 (9%)	247 (89%)	7
I ignored the condition of river banks	30 (15%)	162 (83%)	2	3 (3%)	77 (92%)	4	33 (12%)	239 (86%)	6

characteristic									
I ignored the increase in my annual household income tax	32 (16%)	160 (82%)	2	10 (12%)	70 (83%)	4	42 (15%)	230 (83%)	6
I considered all characteristics equally	137 (71%)	55 (28%)	2	52 (62%)	28 (33%)	4	189 (68%)	83 (30%)	6
Total		**194**			**84**			**278**	

Table 8.8 presents an explorative parametric analysis with regard to the impact of discontinuous preferences on choice. MMNL models are estimated with 150 draws from Halton sequences assuming normal distributions for all parameters and Model 1 is reported as a reference model derived from the sample of respondents who did not always choose the SQ alternative. The rest of the models pertained to the analysis which accounted for discontinuous preferences. Model 2 was derived from a subset of respondents after omitting those who ignored at least one environmental attribute and the Cost attribute. In Model 3, ignored attributes compared to Model 2 were not removed but coded as -888. NLOGIT 4.0 offers a modelling choice strategy according to which the program detects ignored attributes and adjusts the model appropriately without incorrectly assuming a value of zero. Finally, Model 4 was derived from the subset of respondents that replied true to the statement, "I considered all characteristics equally".

Inspection of Table 8.8 reveals that the average LL function at convergence was higher for the model which assumed no discontinuous preferences, apart from the case of Model 3. While this result would indicate that accounting for discontinuous preferences did not lead to an improvement in model performance, this conclusion could not be drawn as the models are not directly comparable. However, comparison of the pseudo-

R^2 statistics suggested that the model which did take into account discontinuous preferences was superior to the model that did not, apart from the case of Model 3.

Across both models in Table 8.8, estimated coefficients were all found to be statistically significant and of the expected sign, while the relative dimensions of the parameter estimates for all of the river attributes corresponded with theoretical expectations of decreasing marginal utility apart from the River Life attribute which remained an anomaly. Finally, as reflected by the *t*-ratios, the precision to which the coefficients of the attributes were estimated varied across the models.

Table 8.8: Models regarding discontinuous preferences

	Model 1	Model 2	Model 3	Model 4
	MMNL	MMNL	MMNL	MMNL
River Life _G	0.913 (2.428)**	0.954 (2.173)**	1.376 (3.990)***	1.271 (2.545)**
River Life _M	1.528 (5.245)***	1.826 (5.078)***	1.502 (5.323)***	1.842 (4.604)***
Appearance _A	3.181 (7.179)***	2.765 (5.133)***	2.808 (7.000)***	3.782 (4.848)***
Appearance _S	2.141 (5.471)***	2.068 (4.252)***	2.008 (5.305)***	2.933 (4.373)***
Recreation _A	1.680 (4.150)***	1.491 (2.958)***	1.270 (3.472)***	1.753 (2.964)***
Recreation _S	1.171 (4.078)***	1.084 (3.173)***	0.898 (3.786)***	1.240 (2.827)***
River Banks	1.858 (5.943)***	1.991 (5.214)***	1.902 (5.796)***	2.403 (4.278)***
Cost	-0.054 (-4.861)***	-0.043 (-3.719)***	-0.041 (-4.689)***	-0.062 (-4.184)***
St. Deviations				
River Life _G	0.670 (0.763)	0.040 (0.058)	1.072 (1.736)*	1.491 (2.206)**
River Life _M	0.165 (0.202)	0.016 (0.026)	0.851 (1.866)*	0.406 (0.555)
Appearance _A	0.641 (1.191)	0.179 (0.344)	0.015 (0.025)	1.059 (1.660)*
Appearance _S	1.603 (3.933)***	1.316 (2.618)***	1.981 (4.910)***	1.984 (3.3695)***
Recreation _A	1.480 (2.258)**	2.453 (3.217)***	1.079 (1.876)*	1.403 (1.577)
Recreation _S	1.258 (3.195)***	1.308 (2.487)**	0.821 (2.042)**	1.344 (2.590)***
River Banks	2.004 (4.579)***	1.567 (2.880)***	1.875 (4.788)***	2.283 (3.269)***
Cost	0.075 (5.945)***	0.058 (4.079)***	0.054 (5.476)***	0.076 (4.328)***
Diagnostics:				
LL	-519.33	-300.97	-532.66	-365.58
χ^2	666.37	408.76	639.71	490.49
Pseudo-R^2	0.390	0.404	0.375	0.401
BIC	561.47	338.92	574.80	405.05
Correctly predicted	55%	56%	55%	56%
Observations	776	460	776	556
# of respondents	194	115	194	139

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%.

Table 8.9 provides estimates of implicit WTP for both levels of improvements from the No Change level for all river attributes (in € per year) for the above reported MMNL discrete choice model specification. The table also reports in parenthesis the 95% confidence intervals estimated using the Krinsky and Robb procedure with 1000 draws, whilst the last columns show the approximate significance levels resulting from the Poe, Severance-Lossin and Welsh test of equality of means.

Inspection of the confidence intervals showed that all implicit WTP estimates were significant. Estimates derived under the specification which did not account for discontinuous preferences tended to be smaller compared to Models 2 and 3 obtained when such preferences were taken into account. However, a test of equality of means did not reveal overall significant differences between the estimates apart from the River Life attribute. In this latter case it seems that accounting for discontinuous preferences resulted in a higher and significant at 10% level implicit price compared to Model 1 which assumed no discontinuous preferences.

Although, the employed analysis is only explorative and further inspection is required, preliminary results do not show strong evidence of systematic differences in WTP between the different model specifications and the differences are in general small. This result concurs with the findings of Carlsson *et al.* (2010) while it conflicts with to previous studies comparing models with and without consideration of ignored attributes (*e.g.*, Campbell *et al.*, 2006).

Table 8.9: Implicit prices (€ per household/year) and confidence intervals (sensitivity to discontinuous preferences)

	Model 1	Model 2	Model 3	Model 4	Model 1 *vs* 2	Model 1 *vs* 3	Model 1 *vs* 4
	Assuming no discontinuous preferences	Assuming discontinuous preferences	Assuming discontinuous preferences	Assuming discontinuous preferences	$IP_{Model 1} = IP_{Model 2}$	$IP_{Model 1} = IP_{Model 3}$	$IP_{Model 1} = IP_{Model 3}$
River Life _G	16.70	21.87	33.79	20.62	0.337	0.055	0.360
	(3.70, 30.17)	(2.68, 44.53)	(18.55, 54.73)	(5.53, 40.29)			
River Life _M	28.85	44.03	37.61	30.69	0.092	0.183	0.424
	(18.63, 42.72)	(27.04, 71.70)	(23.45, 56.42)	(18.87, 47.72)			
Appearance _A	60.58	67.57	70.98	62.94	0.405	0.290	0.442
	(42.76, 92.21)	(39.21, 124.08)	(47.25, 112.52)	(41.55, 98.52)			
Appearance _S	40.99	51.32	51.07	49.03	0.308	0.255	0.278
	(26.61, 65.38)	(26.65, 97.06)	(30.82, 82.74)	(30.72, 77.47)			
Recreation _A	32.14	37.27	32.09	29.18	0.427	0.505	0.413
	(16.79, 55.54)	(11.23, 80.97)	(14.43, 58.86)	(11.50, 52.44)			
Recreation _S	22.56	27.89	23.15	20.80	0.402	0.484	0.432
	(11.15, 37.73)	(8.09, 57.17)	(10.43, 41.81)	(6.35, 37.88)			
River Banks	35.47	48.14	48.11	40.16	0.233	0.193	0.364
	(21.77, 56.05)	(25.46, 90.71)	(28.87, 80.89)	(22.57, 65.22)			

8.4 Summary of main findings

The objective of this chapter was to investigate the effect of choice on the cognitive ability of individuals, the information process, and rules that underlie choices, as well as providing an exploration of the existence of discontinuous preferences. The literature review has identified differences in the perceived complexity, and in the use of heuristics, as well as the presence of various factors in decision-making. Such factors include the role of the social sphere, the knowledge and awareness of the respondent, their emotional involvement, their beliefs about the effectiveness of a project, and other psychological and philosophical parameters. In this survey, a number of follow-up questions attempted to identify psychometric factors related to perceived cognitive difficulty and personal concerns that take part in preference formation, as well as the use of heurists.

Starting from capturing cognitive burden, individuals were asked to report in a 7 point likert scale the difficulty they faced in concentrating on the task, remembering the necessary information, thinking clearly and logically, and choosing the best option. Discrete choice models of various specifications revealed heterogeneity in the ability of respondents to perform in the context of an experimental choice task. A negative and significant cognitive related variable showed that the easier the task the less likely for the respondent to choose the *status quo*, while an HEV specification showed that heterogeneity was observed across respondents and choices. Then, a Swait-Louviere test rejected the hypothesis of identical preferences across the two groups experiencing relatively more or less cognitive burden even after rescaling. Hence, there was evidence that respondents with more or less cognitive burden valued river improvements differently, highlighting the importance of cognition in a CE framework. This was also emphasised by exploring cognition's impact on the estimated CS and consequently on BT performance. In particular, omitting the cognitive ability variable reduced the size of the reported CS. The equality of CS was rejected in three out of four scenarios (MMNL specification) at the 10% significance level. Finally, TEs were reduced considerably when the CS was calculated after omitting the cognitive ability variable.

Subsection 8.2.2 focused on the contribution of other psychometric variables such as making a choice trusting one's instinct and considering what the social environment thinks. Results showed that the addition of these two variables seemed to improve the model, while their omission reduced the size of the reported CS although the equality of CS compared to the full model was not rejected. However, regarding the CS of a restricted model including only the socio-economic variables reduced considerably the size of the CS and differences were statistically significant at the 5% and 10% significance level. Results highlighted the sensitivity of the CS estimation to the use of complex and sophisticated functions rather than simpler theoretical based functions.

Section 8.3 analysed responses to a debriefing question asked straight after the choice tasks which required the respondent to indicate which attribute or attributes they ignored when making their choice. Statistical analysis demonstrated that a significant percentage (82-83%) of respondents in both samples considered the Cost attribute. Overall, considering different ways to account for discontinuous preferences results did not show strong evidence of systematic differences in WTP.

9

CONCLUSIONS

9.1 Introduction

This thesis reports the findings of the application of the CE method in two catchment areas that was carried out to examine the value of improvements in rivers' environment due to the European WFD. The attributes in question were improvement of River Life that coincided with ecological status, Appearance of surface water, Recreation and River Banks condition. Each of these river attributes were represented under different levels according to the action made to enhance the attribute. Each level of improvement, apart from Recreation which was explained schematically on choice cards, was presented to respondents by means of illustrations to accurately represent the current situation and what is achievable within the policy framework. Hence, one of the strengths of this study is that it adopted an approach that places emphasis on the effects of pressures on river's environment, as reflected by the use of attributes, and not the pressures *per se*.

This thesis also attempted to explore preference formation under a different choice frame by including in the last four choice cards along with the above river attributes an extra variable of geographic reference. The location variable was Which River(s) are Improved and its/their levels were: None (for the No Change option), the Boyne, the Suir and Both. The survey also included a PCCV in the form of a follow-up question which described a situation where all river attributes reached their maximum potential and hence coincided with the desirable GES.

The objective of this chapter is to report the major policy and methodological conclusions and recommendations emanating from the thesis. Section 9.2 provides a summary of the main policy relevant findings of this thesis and the major policy implications are drawn out. Section 9.3 reports the main methodological findings and provides a number of recommendations for future research, while the last section (Section 9.4) presents the main weaknesses of the study.

9.2 Policy conclusions and recommendations

Data analysis shows that respondents from the two catchments reacted differently to the survey and hence although the river attributes were considerably valued by local residents of one catchment (the Boyne), residents of the other catchment (the Suir) demonstrated a strong preference for the *status quo* scenario. However, it should not be underestimated that a proportion of respondents chose not to pay for improvements not because they did not hold a value, but in order to express their disapproval to different aspects of the hypothetical scenario - especially the fact that others should pay instead of them. As reported in Chapter 5, the number of protesters was higher (more than double) in the Suir than in the Boyne, demonstrating at the same time regional or catchment differences regarding policy interventions. Furthermore, it should be also acknowledged that respondents' reaction may be to some degree due to the fact that although both rivers are facing pressures and measures are needed, overall the Suir catchment has a higher percentage of good status compared to the Boyne. Considering the fact that the same questionnaire was employed (after a series of pretesting) in both catchments and that interviews were standardised, it is regarded that reported differences are not the product of poor survey design. Other differences between samples were observed for example, with regard to occupation where the Suir sample had more farmers and more respondents in the low social class than the Boyne, as well as that more respondents in the Boyne had higher than secondary education than in the Suir and were more familiar with their local river.

Although the survey was not orientated for a protester analysis, data gave the opportunity to explore to some extent protesters' attitude and hence, reveal the motives behind this behaviour. It is interesting to note that parametric analysis of the profile of protesters in the Suir described for example residents who were old, fully employed and who were thinking who else was paying for improvements. On the other hand, results showed that in the case of the Boyne, being a long time resident in the area, considering river's environmental quality unsatisfactory, thinking who else is paying, making a choice by employing the utility maximizing rule (behaving 'rationally'), living further away from the river and considering that improvements will take place in the respondent's proximity rather than the whole catchment decreased the probability of protesting. It is worth noting that looking more in-depth the two samples' descriptive statistical differences were revealed in parameters such as concern about the environment, knowledge, and attitude towards the local river systems. Given this evidence from a policy perspective, the issue of these disparities for the same improvements between catchments should be considered in decision-making. Findings indicate that Suir catchment residents that live further from Dublin than those of the Boyne were more likely to protest for improvements that entailed payment. Personal belief coupled with findings is that less awareness on water policy, as well as disbelief in the management and distribution of tax revenue from central authorities and less because of differences in the composition of catchments' population could explain to some extent the differences. Hence, policy makers should pay more attention to awareness issues and potential government failures that can trigger reactions towards relevant policies.

On the basis of evidence reported in Chapter 6, improvements in rivers' environment related to WFD implementation reveals priorities that better reflect public preferences. The first observation is that WTP for improvements is different between catchments with the Suir respondents willing to pay only for Moderate levels of River Life and A lot of improvement in the Appearance of the river. The situation is different in the Boyne catchment in which households value all involved improvements. It is suggested that policy decision-makers take this information on board. The general public is supportive of improvements of surface river water and hence these benefits should form part of decision-makers potential programmes of measures for achieving good water status.

Also in Chapter 6, a number of socio-demographic and attitudinal/knowledge/belief characteristics in the respondents were identified as being significant in the discrete choice models, thereby indicating their influence on preferences for river improvements. *Status quo* effects were also distinctive in the Suir sample, as expected from statistical analysis, where some of the respondents were shown to prefer the current situation compared to the improvements. Important characteristics that favoured improvements were respondents having information about current or previous water policy in the country, thinking that the environmental quality of their local river was unsatisfactory, facing less cognitive difficulty and living closer to the river/tributary. The opposite was observed for those who trusted their instinct and considered what their social entourage would expect them to choose. Generally, extended models added to the understanding of the factors which influence the benefits that the public derive from the WFD, and it is advised that this valuable evidence be used to help define programs that are consistent with public expectations.

However, at this point it is necessary to stress some factors that may have influenced marginal WTP. The fact that in Ireland, residents are not familiar with paying for drinking water services or environmental improvements and the lack of a relevant well-established mechanism might have an impact on the reported WTP. Nevertheless, at the same time it should be also reminded that through successive government campaigns residents have become more and more aware of both supply and environmental costs to using water domestically and the impact of other human interactions with water bodies. Another parameter that should be also taken under consideration when assessing the reported values is the environmental condition of the rivers at that specific point in time as well as the general economic and political situation.

In Chapter 6, a transfer of values was also attempted. It is regarded that the role of BT for the valuation of benefits in the context of the WFD application is important since original site-specific data require both money and time. Section 6.4 attempts the application of the method between the two catchments considering comparisons in terms of models' coefficients, WTP and CS estimates. Findings show that even after adjusting for scale differences the choice models of the two catchments were different. Results are more encouraging for BT regarding equality of implicit prices at least under the MNL specification. The final test compared the CS estimates under four different scenarios without however providing encouraging results for BT application. It should be also emphasised the sensitivity of results to the omission or inclusion of the SQ variable in the case of the Suir sample. Overall, findings indicate different signals regarding the validity of BT and therefore it is a tool that should be used with caution from policy-makers.

It should be stressed that since BT performance was not very encouraging in the context of two catchments within the same country, special care should be taken in the transfer of values from other European countries. However, it should be also clear that although the two catchments faced similar problems, differences in site characteristics were also present. Other differences which could not be identified prior to the survey between the populations regarded mainly their disposition to pay for improvements, awareness and perception about local river problems, and participation in river activities. These could account for, to some degree, the poor performance of BT. In addition, it is reminded that different designs were employed at each catchment in order to account for the fact that residents in each catchment may hold different values.

Nevertheless, it is important for policy makers and practitioners to realise that site similarity in terms of environmental conditions and socio-demographic characteristics is not enough information to assure that accurate values are generated by BT exercises. Hence, factors related to attitude towards the environment, knowledge of rivers' environment, and existence of use values should be equally considered. Although CE seems to offer great potential for BT due to the decomposition of total value for any environmental resource into characteristic values, special consideration should be given to its use. Furthermore, regarding the potential of BT, Jacobs (2007, p.42) suggested that: "Few non-market values can be transferred robustly to changes likely to be brought about by the WFD".

Findings from the CVM question reported in Chapter 7 regarding improvements that correspond to GES verify once more that the same river improvements were not equally valued between the two catchments. Hence, distribution of responses reveal that 50% of respondents in the Suir sample had values of €5 or less, while the Boyne had values of €30 or less. WTP estimates were also different with the Boyne reporting a higher value compared to the Suir. As in the CE context, respondents who were aware of water policy issues in Ireland and were familiar with their local river were more willing to pay for river improvements corresponding to GES. From a policy perspective, results show the sensitivity of the value to the method employed (CVM/CE) and therefore decision-makers should be aware of the type of elicitation method that was employed to estimate the value of relevant benefits. Comparing the stated preference estimate with the results from a meta-analysis of international water and wetland contingent valuation studies (Brouwer *et al.*, 1999), the study's value estimate for overall water quality improvement appears to be lower than the average value in previous valuation studies for water quality control of €90 per household per year. On the other hand, considering the CE welfare estimates for the Boyne of between €120 and €180 and the results of other CE surveys (*e.g.*, Brouwer *et al.*, 2010), deviations are not very large.

Finally, attempting a first comparison between elicited benefits and reported costs, some evidence of policy implications is provided. Hence, considering the Boyne sample the WTP for reaching GES is between 1.8 and 6 million euro per year. These values correspond with the PCCV regression and CE MMNL values respectively, reported in Table 7.10, and with the number of households in the Boyne catchment (33,489) according to the 2006 Census data.

On the other hand, a first attempt to quantify the costs required to achieve good status in Ireland is reported in CDM (2010). In this report it is regarded that the total cost of the programme of measures to deliver the stated objectives of the first river basin management plan (2009-2015) for the entire ERBD will be €2,950,000,000. However, as the authors noted, "[T]his is not to say that implementing the WFD will cost this sum, as significant elements are due to priority implementation of existing legislation. Rather, it is to provide the funding agencies with an indication of broad budgetary requirements that will be necessary to achieve the objectives of the WFD" (CDM 2010, p.10-5). Trying to allocate proportionally the total costs likely to be incurred by the Boyne Local Authorities, a rough estimate regarding river surface water could be about €200,000,000. As a result, although at this stage reported cost data is in a continuous process of refinement to allow comparisons, the derived benefit estimates of water quality improvements offer an insight into the contribution of non-market benefits to inform economic impact assessment and help with setting environmental standards for WFD implementation.

Although it would be of interest to relate the elicited WTP values to the average water costs households pay for water to get some idea of the relative value, water charges in Ireland for domestic use are not yet established, while household charges including an element of water services have been recently introduced. According to the latter reform, in 2012 the Government introduced a combined property and water levy of €100 per household per year which is applied independently of household size or income, while the intention is to introduce meter-based water charges for domestic users in 2013 and to create a new public utility, Irish Water.

Regarding water charges and their appropriate level, there have been ongoing discussions and different views have been heard. For example, it was reported that "households will be likely charged €175 until water meters are installed... average household water bills could be as much as €400 per year"[12] or that "[I]f we maintain the current spending on water (incl. investment), if we keep the business rates for water as they are, and if we exempt those on private schemes from the water charges, then full cost recovery (as required by EU legislation) implies an annual charge of 500 euro per household per year."[13] Furthermore, as mentioned previously, the results of this study should be also evaluated through the prism of the political and economic situation in Ireland which had stemmed from the financial crisis of 2008 and involved financial support from the European Union's European Financial Stability Facility and the

[12] http://www.independent.ie/national-news/households-to-be-charged-175-for-water-until-meters-installed-2662625.html
[13] http://www.irisheconomy.ie/index.php/2011/11/09/the-provision-of-water-services/

International Monetary Fund in late 2010. The economic challenges that the country faces, the experienced austerity, the disbelief that the measures are taken without regard to social equity and the widening perception that a corrupt elite is responsible for the state of the economy, are expected to impact reforms.

9.3 Methodological conclusions and recommendations for future research

Apart from eliciting the values of river improvements due to the WFD, this thesis attempted to address a number of methodological issues. Considering the costs involved in discrete CE surveys, the generation of more statistically efficient experimental designs to minimise the sample size required to achieve asymptotically efficient and reliable estimates makes sense. Following recent results in market research, an efficient experimental design was employed to improve the efficiency of estimates and a much smaller sample was necessary to achieve asymptotically equivalent results. In addition, more informative experimental designs require less choice situations than the degrees of freedom and attribute level balance properly require and the upper boundary should mainly depend on the intuition about how many choice situations respondents can handle.

Focusing primarily on the analysis of discrete choice data, evaluation of the different models in Chapter 6 indicated the inadequacy of the basic MNL models. While the NMNL models were superior to the MNL models, they did not outperform the MMNL models. From the analysis in Chapter 6, as mentioned in the previous section, there was also evidence that *status quo* effects and individual-specific characteristics can improve considerably model's performance and provide more information on respondents' preferences. Another important finding was that responses revealed unobserved preference heterogeneity after attempting a variety of different econometric specifications. Attempting a more in-depth analysis of Boyne sample responses, different specifications revealed for example the existence of heterogeneity across respondents and choices, alternative specific variance heterogeneity (heteroscedasticity) in the unobserved effects of a specific alternative, but also the existence of heterogeneity in some of the parameter estimates. Hence, from a methodological point of view findings show that respondents' tastes may in fact be heterogeneous and more advanced models can provide a more accurate description of this spread of preferences.

As far as the application of BT is concerned, as presented in the previous section, results did not provide strong evidence in favour of the method for the particular case-study catchments. This is not very surprising considering the fact that the two samples differed in terms of environmental conditions, socio-demographics and their disposition towards paying for improvements. Even after adjusting for scale, differences were preserved. Since all differences between samples could not have been available prior to the survey it is of paramount importance that before any transfer value is attempted a basic survey should be applied in the study of interest in order to investigate populations' general attitudes, familiarity, perceptions towards the environment and awareness background. Therefore as it was also stressed in Chapter 8 in a BT context the availability of secondary data about non-standard information is of paramount importance.

Nevertheless, it is interesting to note that the equality of mean CS tests were sensitive not only to the employed model specification but importantly to the inclusion or omission of the SQ especially for the Suir sample, which exhibited a strong *status quo* effect. This impact was also demonstrated in the magnitudes of the TEs which differed also according to which scenario was considered and which catchment was used as the study site. Furthermore, results from Chapter 7 revealed that CVM reported overall lower TEs. From a methodological perspective, aspects such as which test should be employed for method's validation, whether SQ should be included in CS estimation, what valuation method should be used and which site should be used as the study site must be taken seriously into consideration by practitioners. Other findings from Chapter 7 showed that CVM provided estimates of less magnitude compared to CE in both samples. Hence, values differed not only between samples but also between valuation methods. This evidence is in favour of the existence of double counting.

The contribution of psychometric factors in preference formation was explored further in Chapter 8. With regard to cognitive ability, the descriptive statistics reported in Chapter 5 revealed that on average the Suir sample reported a higher score than the Boyne meaning that respondents experienced less difficulty answering the choice cards. As far as the degree of difficulty associated with the two different sets of choice cards is concerned, the Boyne sample seemed not to differentiate between them compared to the Suir sample. Discrete choice models in Chapter 8 revealed heterogeneity in the ability of respondents' performance in the framework of an experimental choice task. A negative and significant cognitive related variable showed that the easier the task the less likely the respondent will choose the *status quo*, while a HEV specification showed that heterogeneity was observed across respondents and choices. Furthermore, a Swait-Louviere test showed that respondents that differed in terms of self-reported cognitive burden valued differently environmental improvements. Hence, the findings demonstrate that cognitive ability differed between samples and had an impact on respondents' preferences and preferences' heterogeneity. Finally, analysis focused on exploring the impact of cognitive ability on the estimated CS and consequently on BT performance. In particular, omitting the cognitive ability variable reduced the size of the reported CS and the equality of mean CS was rejected in three out of four scenarios (MMNL specification) at the 10% significance level. As a result, the issue of complexity and heterogeneity in dealing with cognitive burden should be examined more and accounted for in CEs.

In the same chapter, an attempt was made to investigate heterogeneity in information processes and rules that underlie choices. Results from the MMNL discrete choice models of the Boyne sample showed that respondents who made a choice based on what their family and friends would expect them to choose and those who trusted their instinct were more likely to opt for the *status quo* option. Therefore, information management and decision behaviour are issues that need more researchers' attention. In addition, their existence provides a new insight to the theory of choice which could potentially deviate from an individualist rationality. For that reason, a more interdisciplinary approach to modelling choice with contributions from psychology and other relevant social sciences could shed more light on choice process. Other findings were that the addition of the two relevant variables seemed to improve the model, while their omission reduced the size of the reported CS. However, the equality of CS compared to the full model was not rejected. Trying a restricted model including only the socio-economic variables rather than a more sophisticated function reduced CS estimates further and differences were statistically significant at the 5% and 10% significance levels highlighting the sensitivity of the CS estimation to the function specification.

Chapter 8 also analysed the responses to a debriefing question that aimed to identify the existence of discontinuous preferences. Considering different ways to account for discontinuous preferences and calculating marginal WTP, results did not show strong evidence of systematic differences in WTP. However, discontinuous preferences have been detected in other studies having implications on WTP estimates and leading to different policy recommendations which should be addressed in CE's application. In such a case, researchers should find ways to account for such effects and judge if these failures are serious enough to invalidate the welfare estimates. These ways may consist of internal validity tests built into the design or extensive piloting of the survey instrument to investigate preference monotonicity, non-compensatory behaviour and instability.

As stated in Louviere (2006), future research should try to satisfy the need for developing behavioural theory and use it as a basis for formulating and testing models. The author in particular placed emphasis on capturing random error components, developing ways to test how well model results can be generalized, and understanding and modelling how discrete choice models impact the behaviour of respondents. It is also noted that more recognition of the fundamental behaviour role of scale should be given and that the field would benefit from more cross-disciplinary collaboration. This belief is in accordance with McFadden's (2000, p.345) view that an economic model explains "one of many factors in the decision-making environment, with an influence that is often overridden by context effects, emotion, and errors in perception and judgement".

Considering these arguments and the popularity that CEs have gained, especially in the field of environmental economics, future research should concentrate more on behavioural theory. More specifically, as pointed out by Louviere *et al.* (2008) instead of asking respondents to make more choices by increasing the number of choice cards it would be better to ask how they came up with their choices. Indeed, Adamowicz *et al.* (2008) urged researchers to show more interest in exploring other forms of heterogeneity rather than 'residual taste heterogeneity'. As the authors emphasised, "[E]xamples are scale heterogeneity and new and different forms of heterogeneity, such as heterogeneity in the attention individuals pay to choice options and attributes, heterogeneity in the rules that underlie choices, and combinations of these forms of heterogeneity" (Adamowicz *et al.,* 2008, p.10).

Finally, the parametric analysis in Chapter 5 regarding protesters provided an insight of this behaviour. From a methodological point of view, it is interesting to see that for example, the geographical location of the household, the perception about river's condition and other parameters such as cognitive burden, "who else is paying", and behaving 'rationally', impact on protesting. As a result, cognitive burden is not only associated with the occurrence of inconsistent and irrational responses in discrete choice experiments but can also induce a protesting behaviour. In addition, the pooled model was a testament to the differences in protest rates, showing that respondents from the Boyne HA were less likely to protest. Overall, in order to minimise protesting behaviour it is important for the researcher to make clear how the cost of a project is distributed among the population, and who is paying, as well as to try to avoid tasks that entail high cognitive ability.

9.4 Main weaknesses of the study

An attempt is made in this last section of the thesis to present the main weaknesses of the current study. One improvement on the questionnaire design would have been to account for the ordering of the employed valuation methods. In this thesis a PCCV question consistently followed a CE. The properties of elicitation methods are known to be influenced by their positioning within a survey questionnaire (Bateman *et al.*, 2008). Although during cognitive interviews and piloting the survey such a concern was not raised, results from the literature (Baker *et al.*, 2007) have found that PCCV WTP amounts for those respondents asked a PCCV question before a CE were significantly lower than those where the order was reversed. The decision not to rotate the methods was dictated by the desire not to tire respondents too much before the CE task, running however a risk of potential bias.

Issues relating to ordering bias could also be raised regarding the order of the two sets of choice cards, which was kept constant. Hence, one could argue that the impact of the extra catchment/location variable cannot be isolated since accumulated tiredness may have also affected choice or order bias may be present. However, it should be noted that respondents were informed before being presented with the cards that they would be asked to value improvements to their local river and then another set of choice cards would concern improvements in one or both of the catchments involved. Furthermore, focus groups and the pilot survey did not present any worrying results. In addition, such an effect should not be present at least for the Boyne sample in which respondents said when asked if they found the second set of choice cards more demanding than the first, that they did not differentiate considerably. Another reason for not rotating the order of the sets was the requirement to keep the questionnaire simple for interviewers.

Regarding the chosen elicitation method of the CVM task, criticisms support the view that the particular range of amounts shown in the payment card can influence respondent answers. Furthermore, from a strategic behavioural perspective, the method is seen as less robust than the DC format and it is regarded that respondents' optimal strategy may be to bid zero if the expected cost is higher than their true WTP, and to bid at, or just above, the expected cost if this is less than their true WTP (Carson and Groves, 2007). Hence, payment card estimates are likely to be biased downwards. However, DC requires a larger sample and due to budget concerns, its use was prohibitive.

It should be also noted that another weakness of the thesis is related to access to income information. It has been acknowledged that lack of household income causes some concern as it makes it difficult to assess the validity and reliability of the estimated models. In this study over 80% of respondents refused to state their income band and that made it even difficult to apply the imputation method as it requires replacing missing data with estimates of the missing values. Furthermore, it could be also argued that there is a chance that the employed illustrations may not have conveyed information as expected to some respondents who may have preferred photos instead. Finally, there is the possibility that a sequential efficient design could provide greater sampling efficiency however, due to limited budget sampling at different phases this was not possible and hence, the alternative option of an efficient design was adopted.

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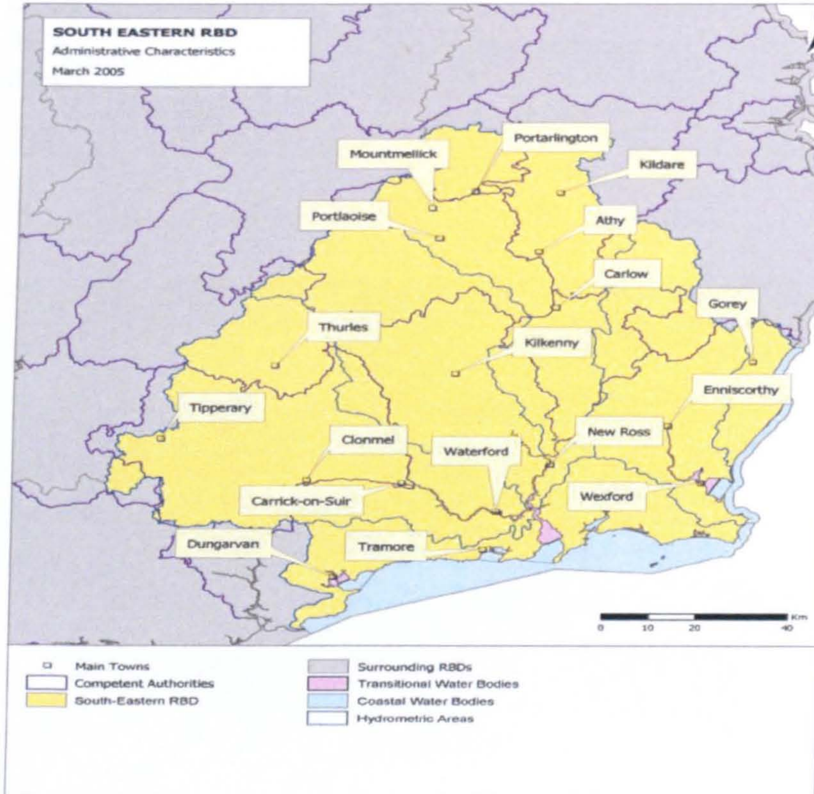
APPENDIX A

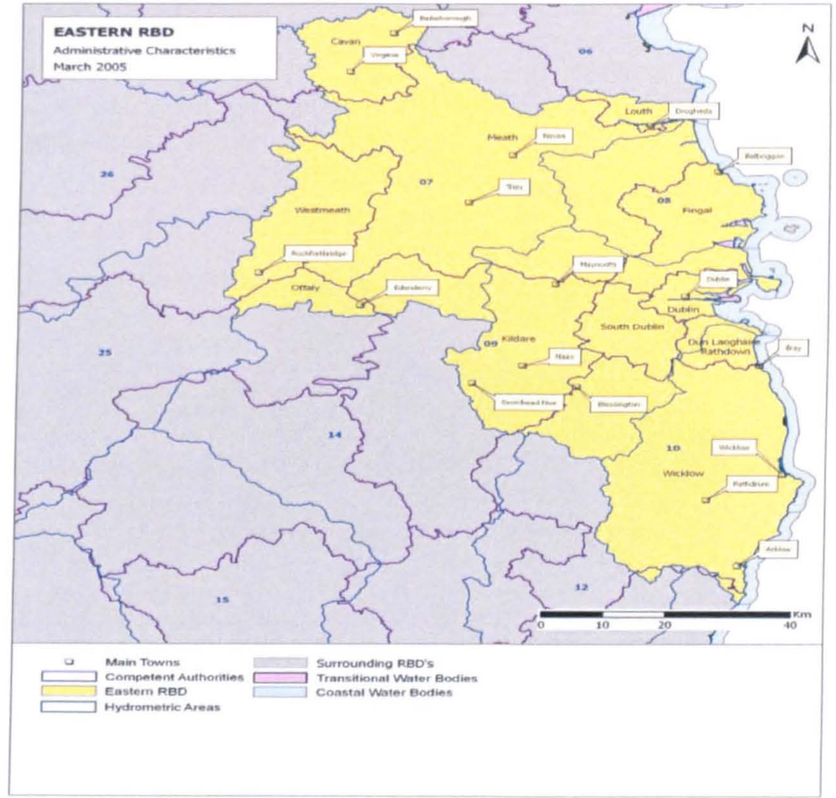
CHARACTERISTICS OF RBDs AND CASE STUDY HAs

River Basin Districts[14]

South Eastern River Basin District (SERBD)



Eastern River Basin District (ERBD)

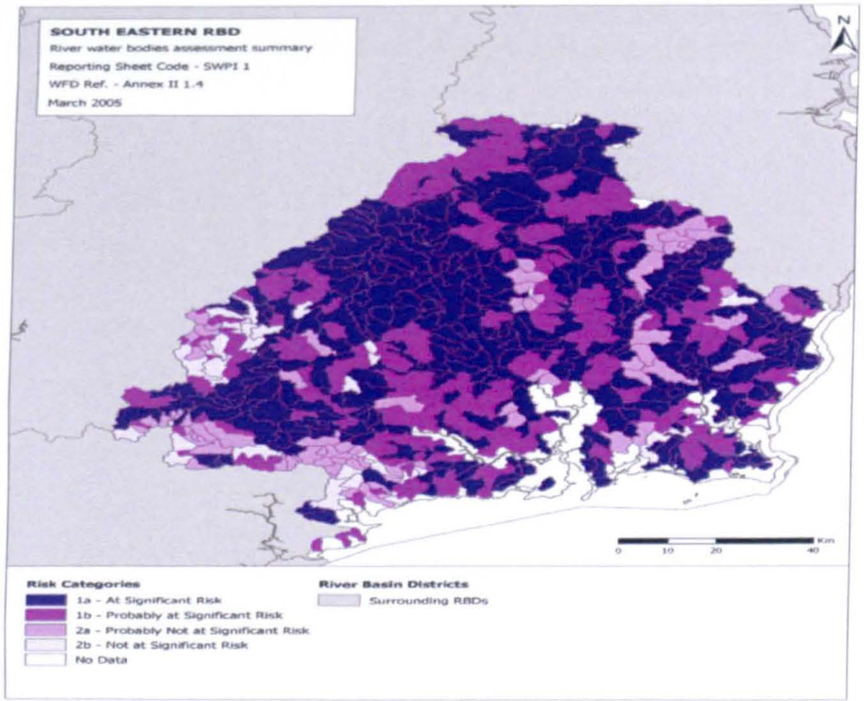


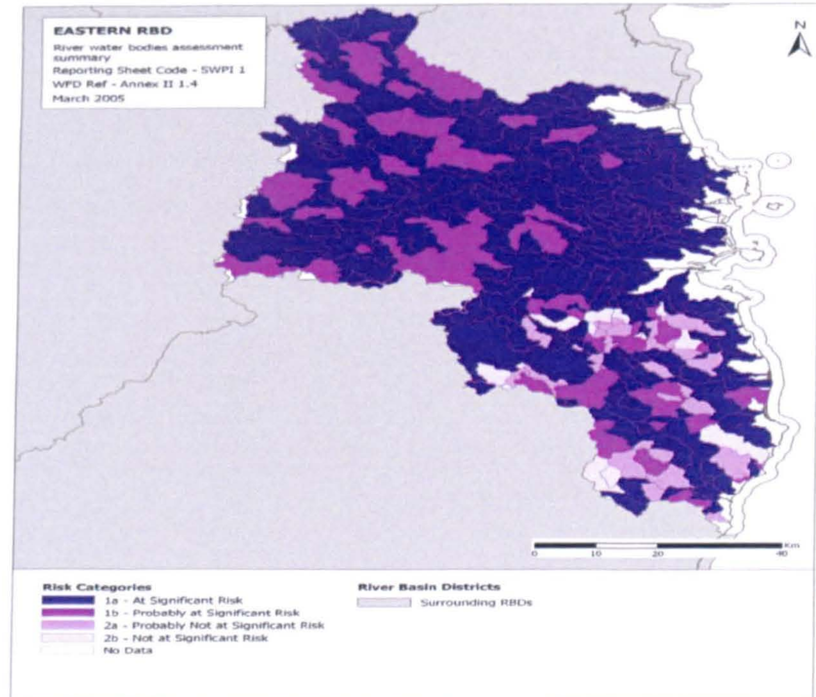
	SERBD	ERBD
Coordinating Local Authority	Carlow	Dublin
Land-area (km^2)	12,834	6,269
Population size	516,177	1,518,000

[14]EPA (2005)

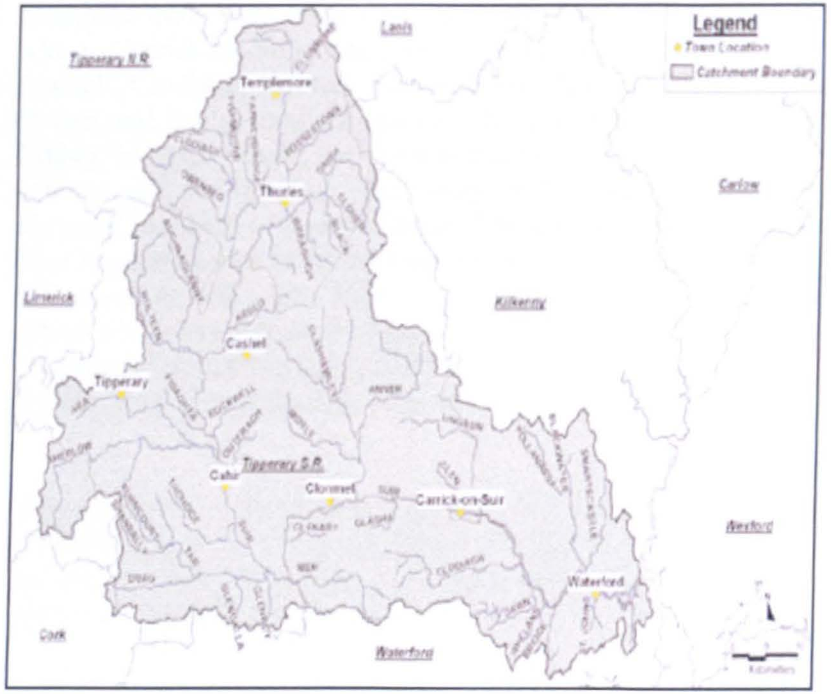
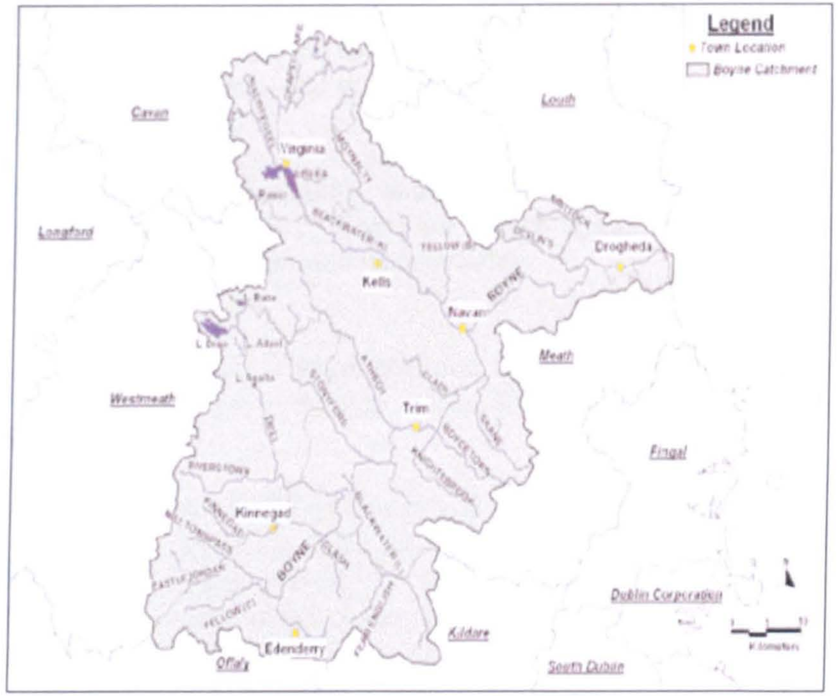
Land-use (%) • Agriculture • Urban • Natural areas	 • 45.4% • 0.1% • 54.4%	 • 75% • 4.67 • 8%
River length (km)	3,114	1,900
River water body numbers	655	356

Risk assessment summary





Main surface water pressures	Diffuse pollution sources mainly associated with agricultural lands and localised urban areas. Morphological pressures and point source pollution are also significant. The main morphological activities are channel drainage and land use change. Municipal and industrial discharges are the key point source pressures within the SERBD. Abstraction pressures are the least widespread. Elevated nitrates in high yielding wells in regionally important aquifers are usually indicative of nitrate pollution originating over large areas i.e. diffuse pollution resulting from the application of organic and inorganic fertilizers and the land spreading of animal wastes that seems to be the case in Suir Catchment (SERBD Characterisation report, 2003)	Land cover is dominated by agricultural area while it is the most highly urbanised and populated basin district in Ireland. Agriculture is deemed responsible for 63% of the phosphorus emitted to the Boyne (EPA, 2005). Pastures comprise 74% of the Boyne catchment while the rest land use is dedicated to arable lands, and crop cultivation, as well as managed forests and peatlands. The second main pressure in Boyne catchment is morphological pressures with the highest incidence of risk to come from channelisation, and to a lesser degree from intensive land use (ERBD Characterisation Report, 2005)

	Suir Catchment (Hydrometric Area 16)	Boyne Catchment (Hydrometric Area 07)
HAs		
Drained Area	The River covers most of Co. Tipperary, part of Co. Waterford in particular the Clodiagh (Portlaw) sub-catchment, and marginal areas of East Limerick, North Cork, Kilkenny (Pollanassa/Blackwater catchment) and a small part of Co. Laois. The Suir catchment covers most of County Tipperary, and stretches into Limerick, Cork Kilkenny and Waterford (Three Rivers Project, 2003)	The Boyne system has a lowland catchment covering the fertile plains of County Meath, a significant area of County Westmeath and parts of Counties Kildare, Offaly, Cavan and Louth (Three Rivers Project, 2003)

Main characteristics as presented in the Irish Fisheries Web Site[15]:	The River Suir rises in the Devil's Bit Mountain, runs South to Cahir and then East to Waterford Harbour. It's an excellent limestone trout river from near its source to where it meets the tide at Carrick-on-Suir. The main tributaries are the Tar, Neir, Annagh, Clodiagh, Multeen and Aherlow. It holds a heavy stock of fish and has several tributaries which also provide god trout fishing. In some places, the stock is heavy to the detriment to the average size, but in others, especially in the lower reaches, there are good numbers of heavier trout. The general character of the river is a long series of rather shallow gravelly glides with a very rich weed growth...The best of the salmon fishing is said to extend downstream from Ardfinnan towards Carrick-on-Suir	The Boyne rises near Edenderry, near Offaly and flows in a northeasterly direction for 70 miles before entering the Irish Sea at Drogheda. This 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 The prime salmon angling water is now to be found between Navan and Drogheda... There are superb stocks of wild brown trout in the river Boyne and its tributaries
River related sampled population (urban/towns, villages)	Waterford, Carrick-on-Suir, Cahir and Clonmel households Carlow is the city of the RBD and the coordinating local authority	Drogheda, Navan & Trim & environs, Slane village households or Edenderry. Dublin is the city of the RBD and the coordinating local authority
	Urban areas account for approximately 1% of the land mass and accommodate 51 % of the catchment population. Major towns in the Suir include Waterford, Carrick-on-Suir, Clonmel, Cahir, Tipperary, Thurles and Templemore	Urban areas in the Boyne catchment account for approximately 0.9% of the land area and accommodate 38% of the catchment population. Major towns in the Boyne catchment include Drogheda, Navan, Kells, Slane, Trim, Edenderry, Baileboro and Virginia (Three Rivers Project, 2003)
Pressures	Agriculture is the predominant landuse in the catchment with 84% of the Suir occupied by arable lands or pasture	Agriculture is the predominant landuse with 91% of the Boyne catchment, occupied by arable lands or pasture
	The agricultural sector (arable and pasture) is estimated to generate the greatest TP load in the Boyne and Suir catchments	For Special Areas of Conservation (SAC) site[17]: The spreading of slurry and fertiliser poses a threat to the water quality of this salmonid river...ongoing maintenance dredging is extremely

[15] www.IrishFisheries.com

	For SAC site[16]: the grassland is intensively managed and the rivers are vulnerable to pollution from run-off of fertilisers and slurry Several industrial developments discharge into the river	destructive salmonid habitat in the area
WFD Register Protected Areas (RPA)[18]	RPA Habitat River RPA Nutrient Sensitive River Special Protection Area (SPA) SAC site[19]/Lower River Suir: Sea Lamprey, River Lamprey, Brook Lamprey, Freashwater Pearl Mussel, Crayfish, Twaite Shad, Atlandic Salmon and Otter Alluvial wet woodlands and Yew Wood. Floating river vegetation, Atlantic salt meadows, Mediterranean Salt meadows, old oak woodlands and eutrophic tall herbs Parts of the site are identified as of ornithological importance. Drinking Water Protected Areas The catchment includes Natural Heritage Areas	RPA Habitat River RPA Nutrient Sensitive River: The main channel Boyne downstream of Navan is designated as a nutrient sensitive area. This is considered to be 'At Risk' (ERBD Characterisation Report, 2005) The River Boyne is a designed Salmonid Water under the EU Freshwater Fish Directive SPA: Boyne Estuary SAC[20]: Rivers Boyne & Blackwater, Boyne Coast & Estuary. Salmon, Trout, River Lamprey. Other species listed in the Irish Red Data Book include Pine Marten, Badger, common Frog and Irish Hare. All these animals with the addition of the Stoat and Red Squirrel are protected under the Wildlife Act The site is a candidate SAC selected for alkaline fen and alluvial woodlands Wet woodland fringes many stretches of the Boyne while the dominant habitat along the edges of the river is freshwater marsh. The secondary habitat associated with the marsh is wet grassland while along much of Boyne and along tributary stretches area

[3] http://www.npws.ie/en/
[4] Ibid footnote 3
[18] ERBD Characterisation Report, (2005)
[19] Ibid footnote 3
[20] Ibid footnote 3

		areas of mature deciduous woodland Drinking Water Protected Areas The catchment includes Natural Heritage Areas
Nitrates[21]	<u>Carrick-on-Suir:</u> <2 mg/lN (in 1979) >≈3 mg/lN (in 2006)	<u>Slane:</u> ≈1.5 mg/lN (in 1982) ≈4 mg/lN (in 2006)
Phosphates[9]	Carrick-on-Suir: >0.04 mg/lP (in 1979) <≈0.04 mg/lP (in 2006)	Slane: ≈0.06 mg/lP (in 1984) ≈0.04 mg/lP (in 2006)
Species	Salmonid River (Atlantic salmon and native brown trout)/ Aherlow River The whole of the Suir system is possibly one of the best trout systems in the country *Margaritifera margaritifera*, a sensitive indicator of water quality, has become extinct in the Suir in the past 25-30 years (EPA, 2007) The River Suir is of particular conservation interest for the presence of a number of Annex II animals (European Communities Habitats Directive) including freshwater Pearl Mussel (*Margaritifera durrovensis*), freshwater crayfish (*Austropotamobius pallipes*), Salmon (*Salmon solar*), Thwaite Shad (*Alosa fallax*) and three species of Lamprey (*Lampetra fluviatilis, Lampetra planeri and Petromyzon marinus*) (SERBD, Initial Characterisation Report, 2003)	Salmon and Trout fishery (main channel)/RPA Salmonid River and Salmonid Water-Boyne Estuary A total of 4 water bodies have been designated as protected areas on this basis. These are located on the Boyne main channel and consist of three river water bodies plus the transitional water body All were 'At Risk'. Reduced Shellfish harvesting in estuaries, Boyne is the only remaining commercial shellfish area in the ERBD (ERBD Characterisation Report, 2005) Pearl Mussel (*Margaritifera margaritifera* is under great threat of extinction and not thought to be sustainable, due to enrichment, and there is a further upward trend in the nitrate level apparent since 2003 adding to the other pressures. Boyne does not harbour this mussel, within this period (EPA, 2007)

[21] EPA (2007)

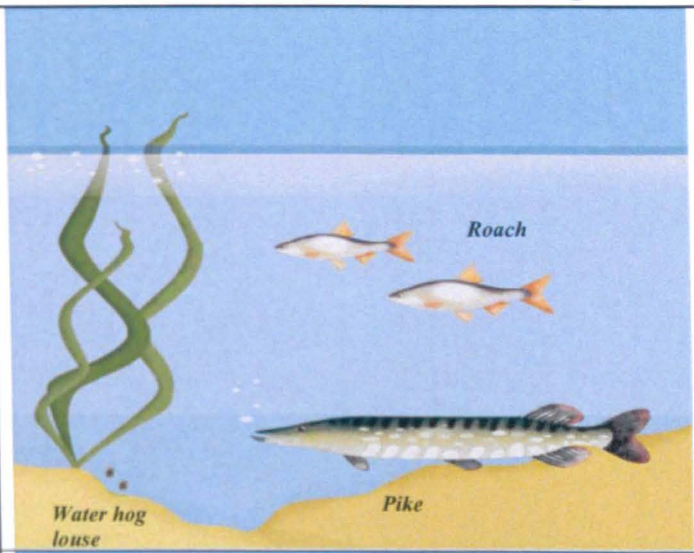
Alien species	*Myriophyllum Aquaticum* (Parrot's Feather) At significant risk to specific parts of the catchment	*Ellodea Nuttallii* (Nuttalls Waterweed) At significant risk to specific parts of the catchment
Activities	Navigation in Carrick-on-Suir. Angling on the lower River Suir (around Carrick and upstream). The best of the salmon fishing is said to extend downstream from Ardfinnan towards Carrick-on-Suir. Walking (trails partly available)	Angling, recreational boating, walking (trails partly available)

APPENDIX B

RIVER ENVIRONMENTAL ATTRIBUTES

River Life: fish, insects, plants

Poor

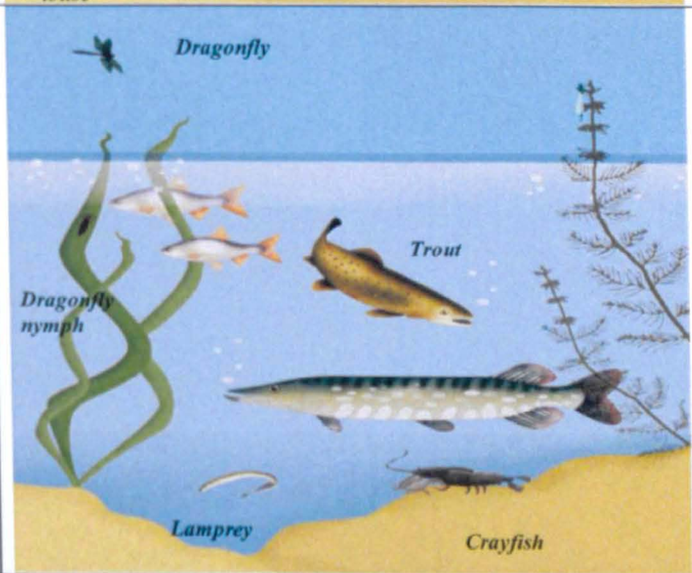


<u>Low</u> number and variety of fish, insects and plants:

Mainly coarse fish

Tolerant species (water hog louse and weed) common

Moderate

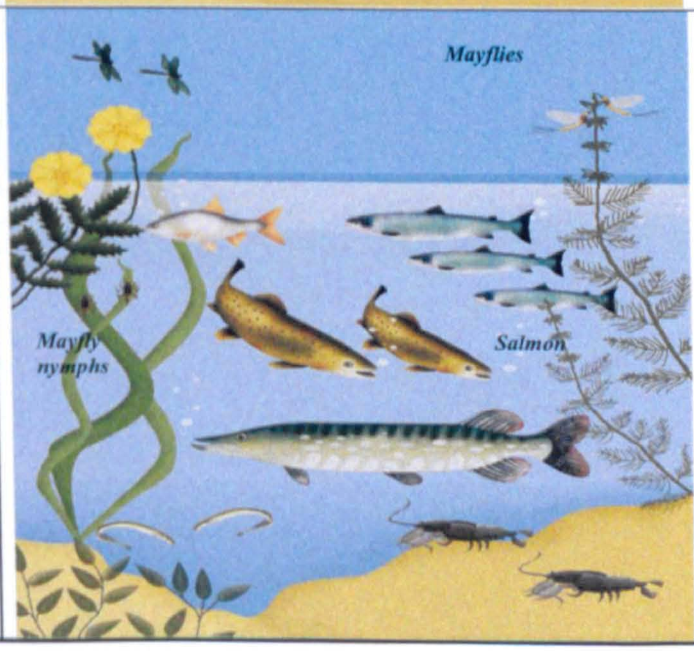


<u>Reduced</u> number and variety of fish, insects and plants:

Coarse fish present but salmon and trout at risk

Sensitive species (lamprey, crayfish, dragonfly, native plants) occasionally present

Good

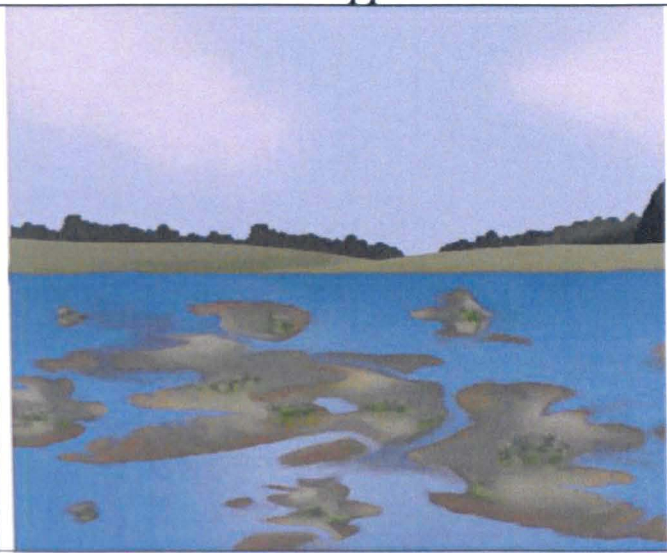
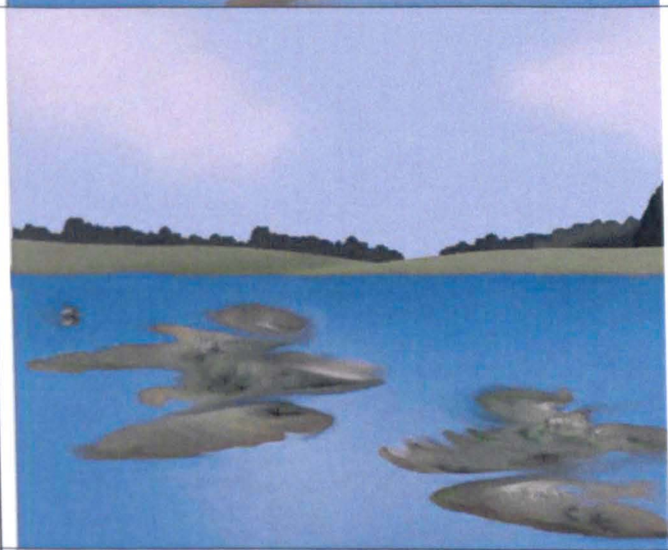
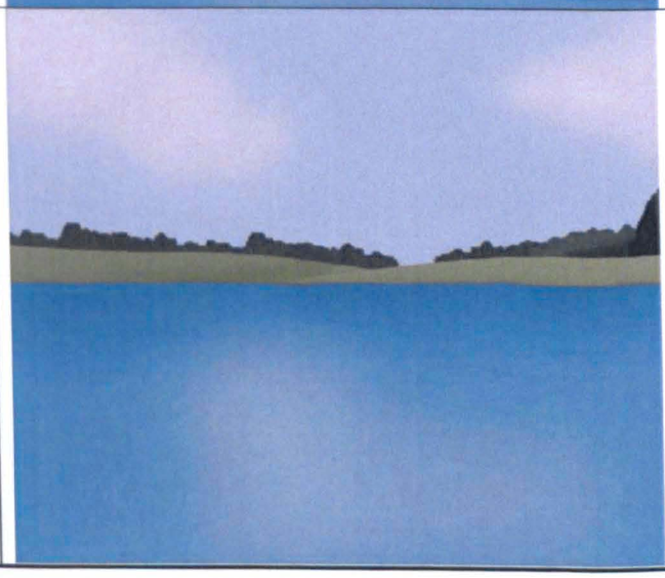


<u>High</u> number and variety of fish, insects and plants:

Healthy populations of salmon, trout as well as coarse

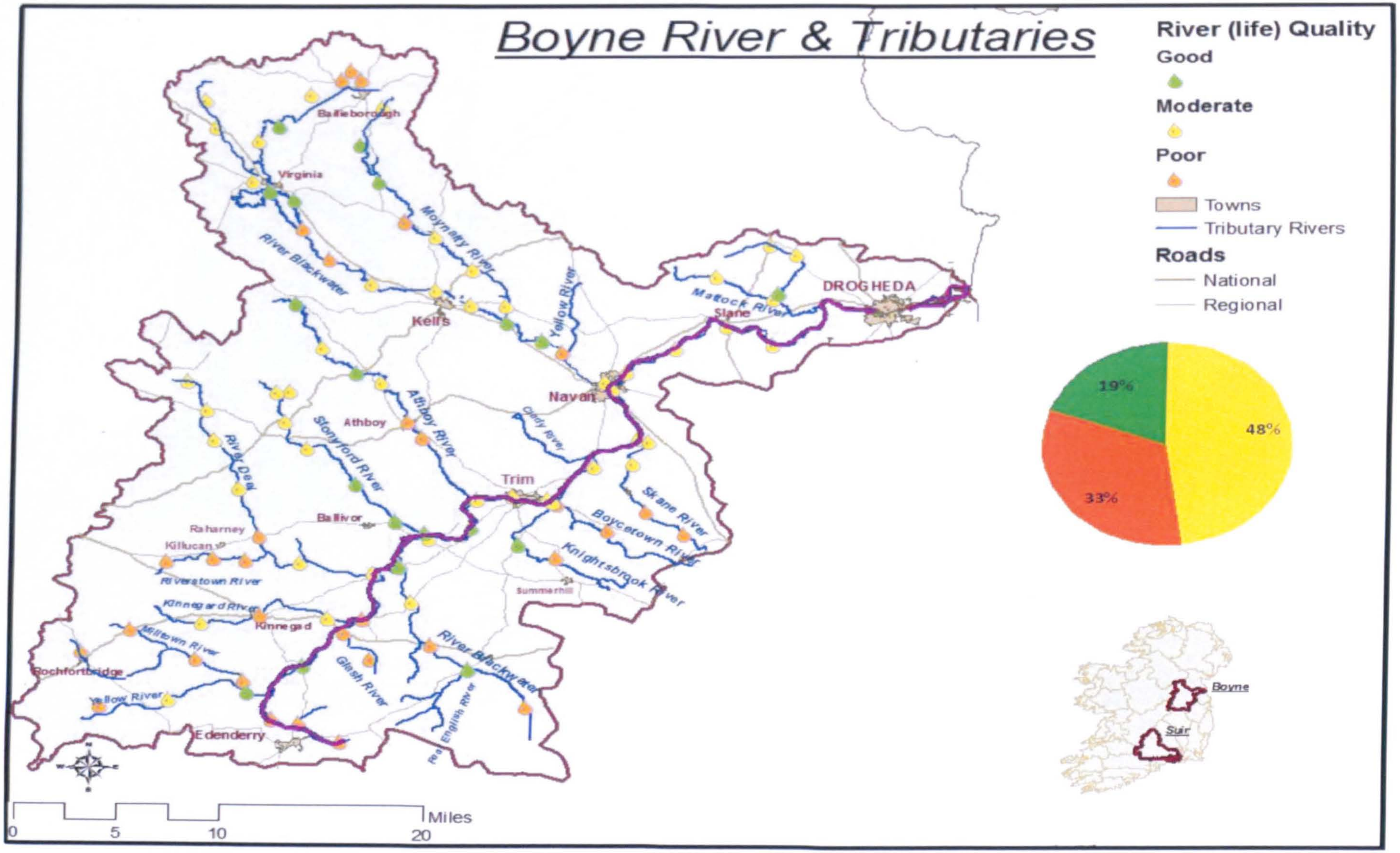
Sensitive species (lamprey, crayfish, mayflies, native plants) present

	River Banks	
Visible erosion that needs repairs		Visible erosion that needs bank repairs (e.g fencing, planting etc) Limited riverside vegetation Animals unlikely to be present
Natural looking banks		Only natural erosion Healthy riverside vegetation Plenty of animals

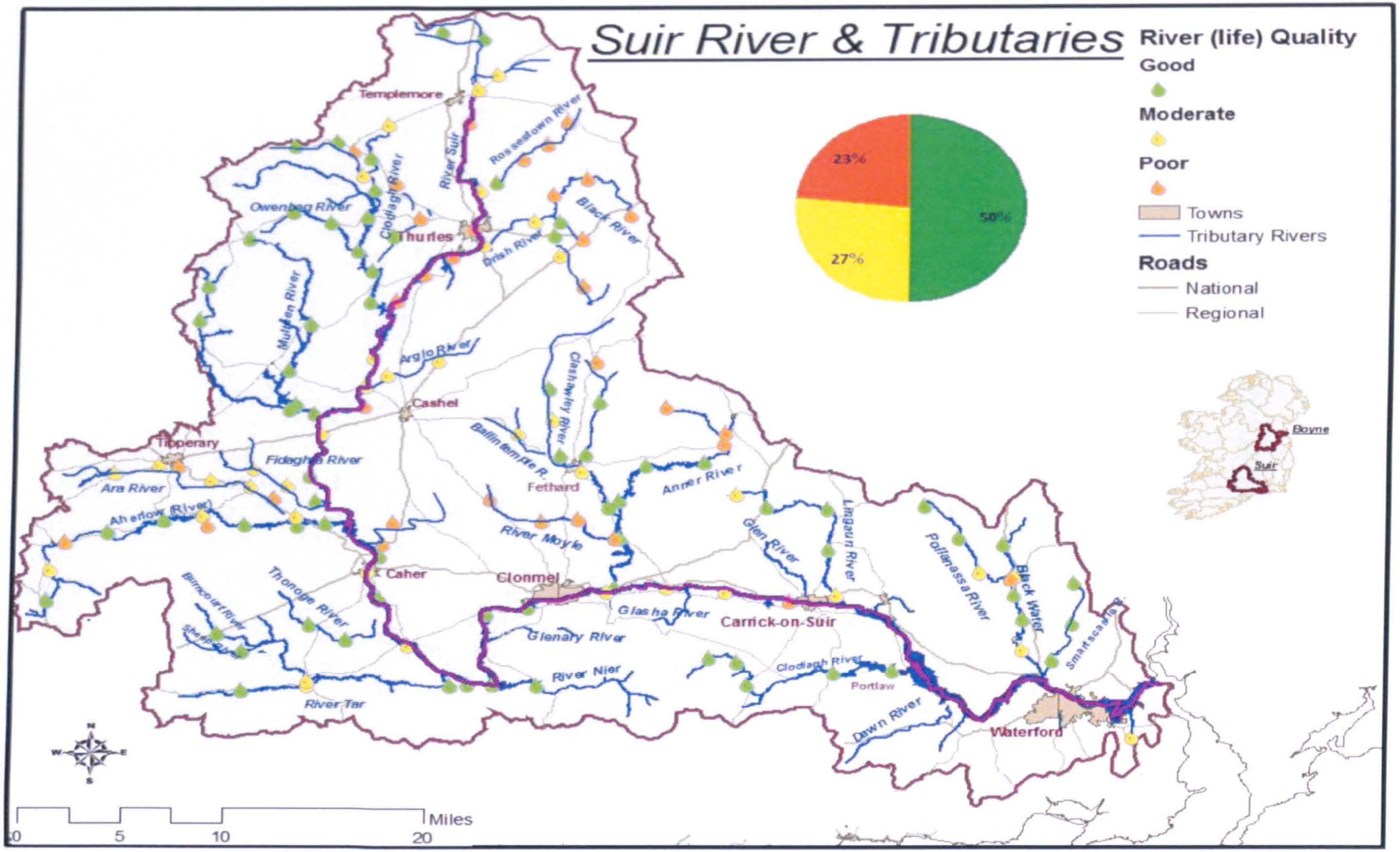
Water Appearance		
No improvement		**Low water clarity (murky or discoloured water)** **Excessive algae**  **Smell of rotting vegetation may be noticeable**
Some improvement		**Moderate water clarity (slightly murky or discoloured water)** **Algae still noticeable** **No smell noticeable**
A lot of improvement		**Good water clarity** **Algae not noticeable** **No smell noticeable**

APPENDIX C

MAPS OF BOYNE AND SUIR HAs



Boyne River & Tributaries
River (life) Quality
Good
Moderate
Poor
Towns
Tributary Rivers
Roads
National
Regional
19%
48%
33%
DROGHEDA
Slane
Navan
Kells
Trim
Athboy
Virginia
Edenderry
Miles
0
5
10
20
Boyne
Suir


Suir River & Tributaries
River (life) Quality
Good
Moderate
Poor
23%
27%
50%
Towns
Tributary Rivers
Roads
National
Regional
Boyne
Suir
Templemore
Thurles
Cashel
Tipperary
Fethard
Caher
Clonmel
Carrick-on-Suir
Portlaw
Waterford
River Suir
Rossestown River
Owenbeg River
Clodiagh River
Black River
Drish River
Multeen River
Arglo River
Clashawley River
Ballintemple R.
Fidaghta River
Ara River
Aherlow River
Anner River
River Moyle
Glen River
Lingaun River
Pollanassa River
Black Water
Thonoge River
Glasha River
Glenary River
River Nier
Clodiagh River
River Tar
Dawn River
Miles
0
5
10
20

APPENDIX D

VALUATION OF RIVER ENVIRONMENTAL IMPROVEMENTS UNDER THE EU WATER FRAMEWORK DIRECTIVE QUESTIONNAIRE

RIVER IMPROVEMENTS SURVEY
BOYNE QUESTIONNAIRE
September/October 2009

I.D. No. (1-4)	Version 1 . ☐ (21-22)	Interviewer No. (5-8)

Ass. No. ____________ (9-12) **Qst. No.** ____________ (13-14) **TNS mrbi/184432/09**

Good morning/afternoon/evening. I am __________ from TNS mrbi, the independent market research agency. We're conducting a survey in this area, on behalf of the University of Stirling in the UK, about the environmental quality of two Irish rivers, river Boyne and Suir. We would like to ask you a few questions – it will take about 20 to 25 minutes. The answers you give will be completely confidential; your answers will be amalgamated with those of others.

NOTE TO INTERVIEWER: IF THE RESPONDENT REFUSES TO PARTICIPATE, PLEASE COMPLETE REFUSALS SHEET – THIS WILL NOT COUNT AS PART OF YOUR QUOTA.

Q.1 RECORD GENDER:

	(15)
Male	1
Female	2

Q.2 We'd like to speak to people in various age groups Can you please tell me your age at your last birthday? **WRITE IN BELOW AND CODE.**

☐☐ (16-17)

NOW CODE

	(18)
Less than 15	1 **CLOSE**
15 -17	2
18-24	3
25-34	4
35-54	5
55-64	6
65+	7
Refused (DO NOT READ)	8 **CLOSE**

Q.3 OCCUPATION OF CHIEF INCOME EARNER

***NOTE** : If retired/unemployed ask previous occupation, If self-employed ask number of employees, If manager/supervisor ask no. of staff responsible for.*

	(19)
A	1
B	2
C1	3
C2	4
D	5
E	6
F1 (50+ acres)	7
F2 (50- acres)	8

IF FARMER (CODE 7 OR 8) AT Q.3, ASK:

Q.4 Are you responsible for running the farm, either solely responsible, or responsible jointly with somebody else?

	(20)	
Yes..	1	(Blank
No	2	23-50)

CHECK QUOTAS - CONTINUE IF RESPONDENT FITS QUOTA

SECTION A: GENERAL ATTITUDES AND ACTIVITIES

SHOW MAPS FOR BOYNE & SUIR. ON EACH MAP INDICATE THE RIVER AND ITS TRIBUTARIES

Q.A1a What do you know about the river Boyne and its tributaries? **MULTICODE**

Q.A1b What do you know about the river Suir and its tributaries? **MULTICODE**

	Q.A1a Boyne River		**Q.A1b Suir River**		
I have not ever heard of this river	01	(73-74)	01	(51-52)	
I know that it exists, but have not visited it	02	(75-76)	02	(53-54)	(Other
I know its historical or current uses	03	(77-78)	03	(55-56)	63-72)
I visit / have visited the river	04	(79-80)	04	(57-58)	
I am aware of its water quality problems	05	(81-82)	05	(59-60)	(Other
Other (specify __________________)	97	(83-84)	97	(61-62)	85-94)

IF HAVE VISITED RIVER BOYNE (CODE 4 AT Q.A1a), ASK:
SHOW MAP FOR BOYNE

Q.A2 Looking at the map and thinking of river Boyne and its tributaries, in the last 12 months, approximately how many trips / visits did you make to partake in the following recreational activities related to the river Boyne? **READ OUT**. **RECORD NUMBER. IF DON'T KNOW CODE 999. IF NONE CODE 000.**

READ OUT ↓	No. of **VISITS** in last 12 months			
1. Walking, jogging, picnic along the banks..........				(113-115)
2. Nature and bird watching, sight seeing				(116-118)
3. Rowing, boating, canoeing or cruising				(119-121)
4. Fishing				(122-124)
5. Swimming				(125-127)
6. Other...				(128-130)

(Blank
131-150)

FOR EACH ACTIVITY UNDERTAKEN AT Q.A2, ASK;

Q.A3 On **the last occasion** that you took a trip for each of your chosen activities to the river <u>Boyne</u>, approximately what distance, in miles, did you travel from home to get to the river?
<u>RECORD NUMBER TO NEAREST MILE. IF DON'T KNOW CODE 999.</u>

<u>READ OUT</u>

↓	No. of **MILES** from home	
1. Walking, jogging, picnic along the banks		(169-171)
2. Nature and bird watching, sight seeing		(172-174)
3. Rowing, boating, canoeing or cruising		(175-177)
4. Fishing		(178-180)
5. Swimming		(181-183)
6. Other		(184-186)

<u>ASK ALL</u>
Q.A4 Is there another river apart from river Boyne including its tributaries that you go to for recreational pursuits?

	(187)
Yes	 1
No	 2

Q.A5 And what is the name of this river? **<u>INTERVIEWER: IF MORE THAN ONE MENTION, ASK FOR NAME OF RIVER RESPONDENT VISITS MOST FREQUENTLY</u>**

Q.A6 How many trips / visits for recreational pursuits in general did you make to ______ (BRING IN NAME OF RIVER MENTIONED IN Q.A5) in the past year?

Q.A7 What is the approximate distance from your home to ______ (BRING IN NAME OF RIVER MENTIONED IN Q.A5) in miles?

(188-190) **Q.A5** **NAME OF RIVER / TRIBUTARY** ↓	(191-193) (194-196) **Q.A6** **No. of VISITS in last 12 months**	**Q.A7** **No. of MILES from home**

<u>IF AWARE OF RIVER BOYNE(CODE 2/3/4/5 AT Q.A1a), ASK:</u>
<u>SHOWCARD</u>

Q.A8 How would you describe the general environmental quality (water and surroundings) of River <u>Boyne</u> (including its tributaries)? **<u>SINGLE CODE</u>**

	(232)
Very satisfactory	1
Satisfactory	2
Neither satisfactory nor satisfactory	3
Unsatisfactory	4
Very unsatisfactory	5

Refused	6
Don't know	7

ASK ALL

Q.A9 Are you aware of any specific water related policy taking place in Ireland at the moment or in the past?

(237)

Yes	 1
No	 2

SECTION B: VALUATION SCENARIO OF RIVERS' QUALITY CHARACTERISTICS

INTERVIEWER, READ OUT:

This survey is concerned with your opinions about the quality of rivers Boyne and Suir (including their tributaries)

INTERVIEWER: SHOW MAPS AGAIN AND EXPLAIN WHICH IS THE MAIN CHANNEL AND MAIN TRIBUTARIES OF THE RIVERS. AT THIS POINT DON'T REFER TO DROPLETS. KEEP THE MAPS IN FRONT OF THE RESPONDENT

INTERVIEWER, READ OUT:

- Rivers' quality has been affected by actions of households, farms, businesses and by climate change.
- Environmental improvements such as better treatment of waste-water, river bank repairs, and control of weeds are needed.
- These improvements would come at a cost to households like yours and we are interested to know your opinions about what kinds of improvements we should be aiming for. Households in both catchments are asked to contribute when improvements take place in both rivers. When improvements are unique to your catchment area, only local households are asked to contribute.
- The cost would be met through increases in income tax and/or VAT.
- Assume that any reservations you may have in relation to mismanagement are being properly addressed and that payments will be specifically ring-fenced for improvements happening in the specified river(s).
- What is important to consider is that improvements will have a cost for your household for the **next 10 years.**
- These payments are in addition to any payments for water usage that you may pay so far.

For the purposes of this study, we think about river quality in terms of **four** characteristics:

The first characteristic is **river life** which refers to the composition and abundance of fish, insects and plants. The **SHOWCARD RIVER LIFE** presents what will be the situation if there is no change and which are the possible improvements if action takes place. **INTERVIEWER: SHOW RIVER LIFE SHOWCARD AND POINT OUT THAT ON THE MAPS THE DROPLETS SHOW THE QUALITY OF RIVER LIFE. READ THROUGH THE RIVER LIFE SHOWCARD WITH THE RESPONDENT. THEN ALLOW THEM A FEW MINUTES TO READ THROUGH IT AGAIN THEMSELVES.**

Another characteristic is the **water appearance and smell**. Specific stretches of the river are prone to excessive plant growth, low water clarity and possibly noticeable bad smells. The **SHOWCARD WATER APPEARANCE** gives more details on this problem. Please note that improvements will not affect your drinking water quality, and they will not be responsible for cleaning up general rubbish like plastic bags and bottles. **INTERVIEWER: SHOW WATER APPEARANCE SHOWCARD. READ THROUGH THE WATER APPEARANCE SHOWCARD WITH THE RESPONDENT. THEN ALLOW THEM A FEW MINUTES TO READ THROUGH IT AGAIN THEMSELVES.**

Rivers' health is also identified by the condition of the **river banks.** The **SHOWCARD RIVER BANKS** gives more details. **INTERVIEWER: SHOW RIVER BANKS SHOWCARD. READ THROUGH THE RIVER BANKS SHOWCARD WITH THE RESPONDENT. THEN ALLOW THEM A FEW MINUTES TO READ THROUGH IT AGAIN THEMSELVES.**

Finally, river's quality is related to the **number of activities** that is possible to take place in each river. Please note that improvements will not affect access to recreation directly.

INTERVIEWER, KEEP THE MAPS AND SHOWCARDS IN FRONT OF THE RESPONDENT DURING THE REMAINDER OF THE INTERVIEW.

Soon you will be presented with eight cards. In each card different combinations of the rivers' characteristics are shown describing how the environmental situation might change in the future if actions are taken to improve matters. The first four cards will concern the case where improvements happen only in the Boyne River. The last four will concern the case where improvements happen in either Boyne, Suir or in both rivers. In all eight cards you will be asked to make a choice.

SHOWCARD

Q.B1 Here is **an example** of such a choice card that improvements happen only in Boyne River.

INTERVIEWER: PRESENT SHOW CARD AND TALK THROUGH THE CHOICES

	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 your household for the next 10 years	€0 ☐	€5 ☐	€80 ☐

- In each of the cards like this one you will be given the choice of making no change or selecting one of two alternatives for improvement, which are called Option "A" and Option "B".
- The option of "No Change" remains the same in all the cards and it never involves a payment. It describes the current situation.

- However, choosing Options "A" or "B" would mean an improvement and a cost to your household each year for the next 10 years.
- For example, Option "A" in this card:

  Represents an option which would lead to a situation where all environmental characteristics are improved (river life, appearance, recreation, banks) at a cost of €5 per year for the next 10 years.

- Option "B":

  Represents an option which would lead to an even higher improvement in river life, appearance and recreation but a worsening in the banks condition. The expected annual cost of this option to your household is €80 per year for the next 10 years.

  Which of the three options would you prefer?

INTERVIEWER, MAKE SURE THE PARTICIPANT UNDERSTANDS THE CHOICE SET. GO THROUGH IT AGAIN IF NECESSARY.

INTERVIEWER, PLEASE READ OUT THE FOLLOWING INFORMATION

You will now be presented with a series of similar choice sets.

- I would like you to identify the option you most prefer for each choice card.
- Remember to consider each of the eight choice cards separately and the options presented as if they are real and the only ones available.
- ***There are no wrong or right answers.*** We are just interested in your opinion.
- If you think that the amount of money involved with an improvement is too much, ***simply choose the "No Change" option.***

Finally, we would like to mention that some people say 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.

For this reason, please consider:

- The impacts on you and your family of improving river(s) quality
- Imagine your household **actually paying** the amounts specified **for the next 10 years**
- Consider that your household payments and income may change in the future

INTERVIEWER PLEASE RECORD BLOCK. PLEASE NOTE THE CHOICE CARDS MUST BE SHOWN ONE BY ONE AND THE RESPONDENT IS NOT ALLOWED TO LOOK BACK ON PREVIOUS CHOICE CARDS. MAKE SURE TO REGISTER CHOICE ON EACH CHOICE CARD BEFORE PROCEEDING. MAKE SURE TO ATTACH CHOICE CARD WITH REGISTERED ANSWERS TO QUESTIONNAIRE.

INTERVIEWER: WRITE IN BLOCK NUMBER IN Q.B2. RECORD RESPONDENTS ANSWER BY CIRCLING CODE 1, 2 OR 3 IN Q.B2a.

Q.B2 **BLOCK NO:** [ ] (310)

INTERVIEWER, PLEASE REMIND: THESE FOUR CARDS CONCERN IMPROVEMENTS ONLY IN BOYNE.

Q.B2a

	No Change	Option A	Option B	
Card 1	1	2	3	(311)
Card 2	1	2	3	(312)
Card 3	1	2	3	(313)
Card 4	1	2	3	(314)

ASK Q.B3 &Q.3a TO THOSE WHO CHOSE EITHER "OPTION A" OR "OPTION B" FOR ANY OF THE CHOICE SETS IN Q.B2a. OTHERWISE GO TO INSTRUCTION BEFORE Q.B4.

SHOWCARD

Q.B3 Thinking about how you made your choice in the above 4 choice cards, please indicate which of the following statements are true or false in describing the way you came up with your choice? **READ OUT EACH STATEMENT IN TURN – ROTATE START**

		True	False	
a)	I ignored the river life characteristic	1	2	(413)
b)	I ignored the water appearance characteristic	1	2	(414)
c)	I ignored the recreational activities characteristic	1	2	(415)
d)	I ignored the condition of river's banks characteristic....................	1	2	(416)
e)	I ignored the increase in my annual household income tax............	1	2	(418)
f)	I considered all characteristics equally.......................................	1	2	(600)

SHOWCARD

Q.B3a I'd now like you to rank each of the following four characteristics related to the environment of the river Boyne and its tributaries in terms of which you consider to be the most important down to the least important, where 1 is the most important, 2 is the second most important, etc. and 4 is the least important. **ASK REPSONDENT TO USE ALL NUMBERS (1 to 4) ONLY ONCE**

	Rank	
River life (fish, insects, plants) being reduced and / or threatened		(215)
Appearance of water and smell due to chemical/wastes run-off....		(602)
Limited recreational activities		(217)
Bad condition of the river's banks		(218)

(Blank 603-605)

Q.B4 You will now be presented with four cards that concern improvements that happen in Boyne, Suir or in both rivers. Here is an example of such a card. **INTERVIEWER: PRESENT SHOW CARD AND INDICATE THE EXRTA ATTRIBUTE – i.e. "Which rivers are improved"**

	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
Which river(s) are improved?	None	Boyne	Both
Increase in annual tax payments by your household for the next 10 years	€0 ☐	€5 ☐	€80 ☐

PLEASE CONSIDER EACH OF THE CARDS SEPARATLY AND THE OPTIONS PRESENTED AS IF THEY ARE REAL AND THE ONLY ONES AVAILABLE.

Q.B4a

	No Change	Option A	Option B	
Card 5	**1**	**2**	**3**	(315)
Card 6	**1**	**2**	**3**	(316)
Card 7	**1**	**2**	**3**	(317)
Card 8	**1**	**2**	**3**	(318)

ASK Q.B5a &Q.B5a TO THOSE WHO CHOSE EITHER "OPTION A" OR "OPTION B" FOR ANY OF THE CHOICE SETS IN Q.B4. OTHERWISE GO TO SECTION C (I.E. Q.C1).

<u>SHOWCARD</u>

Q.B5 Thinking about how you made your choice in these last 4 choice cards, please indicate which of the following statements are true or false in describing the way you came up with your choice? **<u>READ OUT EACH STATEMENT IN TURN – ROTATE START</u>**

		True	False	
a)	I ignored the river life characteristic	1	2	(606)
b)	I ignored the water appearance characteristic	1	2	(607)
c)	I ignored the recreational activities characteristic	1	2	(608)
d)	I ignored the condition of river's banks characteristic.....................	1	2	(609)
e)	I ignored the "which rivers are improved" characteristic.................	1	2	(610)
f)	I ignored the increase in my annual household income tax............	1	2	(611)
g)	I considered all characteristics equally...	1	2	(612)

(Blank 613)

<u>SHOWCARD</u>

Q.B5a I'd now like you to rank each of the following aspects from 1 to 3 in terms of which was most important to least important when making up your mind, where 1 is the most important and 3 the least important. **<u>ASK REPSONDENT TO USE ALL NUMBERS FROM 1 TO 3 ONLY ONCE</u>**

	Rank	
The characteristics that are being improved (river life, appearance etc).............................		(428)
The river(s) that are being improved..............		(429)
Annual household income tax		(430)

SECTION C: FOLLOW-UP QUESTIONS

ASK ALL

Q.C1 Did you find the last set of four cards more difficult to answer compared to the first set of four that concerned only the local river?

(613)

Yes 1
No 2

IF YES FOUND LAST SET OF CARDS MORE DIFFICULT (CODE 1) AT Q.C1, ASK: SHOWCARD

Q.C2a Thinking of the last 4 cards, for each statement I read out, and using a scale of 1 to 7 where 1 means 'extremely difficult' and 7 means 'extremely easy', please tell me overall how difficult or easy did you find.................?

READ OUT EACH STATEMENT – ROTATE START. SINGLE CODE PER STATEMENT

	Extremely difficult						Extremely easy	Don't know	
...concentrating on the choice task?	1	2	3	4	5	6	7	8	(319)
...remembering the necessary information for making your choice?	1	2	3	4	5	6	7	8	(320)
...thinking clearly and logically?	1	2	3	4	5	6	7	8	(321)
...choosing the best option for you?	1	2	3	4	5	6	7	8	(322)

IF NO DID NOT FIND LAST SET OF CARDS MORE DIFFICULT (CODE 2) AT Q.C1, ASK: SHOWCARD

Q.C2b Thinking of all 8 cards, for each statement I read out, and using a scale of 1 to 7 where 1 means 'extremely difficult' and 7 means 'extremely easy', please tell me overall how difficult or easy did you find...? **READ OUT EACH STATEMENT – ROTATE START. SINGLE CODE PER STATEMENT**

	Extremely difficult				Extremely easy			Don't know	
...concentrating on the choice task?	1	2	3	4	5	6	7	8	(636)
...remembering the necessary information for making your choice?	1	2	3	4	5	6	7	8	(637)
...thinking clearly and logically?	1	2	3	4	5	6	7	8	(638)
...choosing the best option for you?	1	2	3	4	5	6	7	8	(639)

ASK ALL
SHOWCARD

Q.C3 In your opinion, thinking about the previous 8 choice cards which of the following statements are true and which are false? **READ OUT EACH STATEMENT - ROTATE START.**

	True	False	
The payment concerned improvements in the stretches of the river(s) that are the closest to me	1	2	(325)
When deciding on the payment I fully considered what I would have to forgo in order to afford that payment	1	2	(326)
When deciding on the payment I was thinking who else was going to pay for the improvements	1	2	(328)
When deciding on the payment I was thinking of the overall cost of these improvements	1	2	(329)
I chose the option most likely to happen as I think most of the people will choose that too	1	2	(614)
I chose the option thinking what my family and friends would expect/like me to choose	1	2	(615)
I chose the option that I thought was right given the improvements, the river(s) involved and my available income	1	2	(616)
I chose by only trusting my hunches	1	2	(617)

ASK ALL

SHOWCARD

Q.C4 I would now like to ask you to consider a new card, which is slightly different than the previous 8 choice cards. This card shows a single improvement option for River Boyne where river life, water appearance, recreational activities and river banks condition reach their best potential. What amount on this card, **[HAND RESPONDENT "PAYMENT CARD"]** or any amount in between, is the maximum increase in your annual household income tax that you would be willing to pay **each year**, for the next 10 years to improve the quality of the River Boyne to the best conditions as shown in Option A? **RECORD AMOUNT RESPONDENT IS WILLING TO PAY EACH YEAR.**
IF RESPONDENT NOT WILLING TO PAY ANYTHING, WRITE IN 0000.

	No Change	Option A
River life: fish, insects, plants	Poor	Good
Water appearance	No improvement	A lot of improvement
Recreational activities	Walking Boating ~~Fishing~~ ~~Swimming~~	Walking Boating Fishing Swimming
Condition of river banks	Visible erosion that needs repairs	Natural looking banks
Annual household income tax	€0	€ --------- **per year** (for the next 10 years)

PAYMENT CARD				
€0	€10	€25	€50	€90
€1	€12	€30	€55	€100
€3	€15	€35	€60	€120
€5	€18	€40	€70	€150
€8	€20	€45	€80	€200
Other (please specify ______________________)				

WRITE IN (to the nearest EURO) (618-621) | € | | | | |

Don't know 9999

ASK Q.C5 TO THOSE WHO CHOSE "NO CHANGE" FOR ALL 8 CHOICE SETS IN SECTION B AT Q.B2a AND Q.B4a AND/OR STATED "€0" ("NO CHANGE" OPTION) AT QC4.

SHOWCARD

Q.C5 Looking at the showcard, can you tell me what were your reasons for choosing the "No Change" option? **MULTICODE**

I cannot afford to pay	01	(351-352)
I object to paying taxes	02	(353-354)
The improvements are not important to me	03	(355-356)
The "No Change" option is satisfactory	04	(357-358)
The Government/Council/other body should pay	05	(359-360)
I don't believe the improvements will actually take place	06	(361-362)
Those who pollute the river(s) should pay	07	(363-364)
I don't use the river(s)	15	(622-623)
I am not interested in improving rivers' quality in general.........................	16	(624-625)
I need more information to make such a decision..................................	17	(626-627)
There was too much information and I was confused..............................	18	(628-629)
I didn't understand the information in the questionnaire..........................	19	(630-631)
I think the situation presented is too hypothetical....................................	20	(632-633)
I think the question is morally offensive	21	(634-635)
Don't know	97	(375-376)
Other (please specify(______________________)	99	(377-378)
	(Other 379-388)	

SECTION D: SOCIO – ECONOMIC CHARACTERISTICS.

(Blank 636-639)

ASK ALL

READ OUT

Finally, in order to provide us with a profile of the people who have participated in this survey and to make sure that those we are surveying are from a wide range of backgrounds, I'm going to ask you some general questions about yourself. All of the information will be kept *anonymous and confidential*.

Q.D1 How long have you lived in the area?

| | | years(501-502)

Q.D2 How many people live in your household, including yourself?

(503)

One	1
Two	2
Three	3
Four	4
Five	5
Six	6
Seven	7
Eight or more	8
Refused	9

Q.D3 How many people in your household are aged 16 years or younger?

(504)

One	1
Two	2
Three	3
Four	4
Five	5
Six	6
Seven or more	7
None	8
Refused	9

Q.D4 And which one of the following apply to you? **READ OUT. SINGLE CODE**

(505-506)

Working full-time (occupation/paid job of 30+ hours per week)	01	
Working part-time (occupation/paid job of 18-29 hours per week)	02	
Working part-time (occupation/paid job of 17 or less hours per week)	03	
Student	04	
Housewife	05	
Retired	06	
Unemployed	07	
Unable to work due to sickness or disability	08	(Other
Other (please specify________________________)	97	507-516)

Q.D5 Are you currently a member of a conservation or environmental activity group, such as An Taisce, Friends of the Earth / Greenpeace, a local wildlife trust, etc. or a member of a local recreation club, such as an angling or walking club?

(529-530)

Yes-specify name of club(e.g.SOS) ________________________	01	(Other
No	02	531-532)

Q.D6 Do you think of yourself as being concerned about the environment?

(640)

Yes 1
No 2
Not sure 3

(Blank 641-650)

ASK ALL

Q.D7 Which level best describes the highest level of education you have obtained until now?
IF RESPONDENT IS STILL STUDYING ASK: Which level best describes the highest level of education you have obtained until now?

(542)

Primary school 1
Secondary school - Inter/Junior Certificate.................... 2
Secondary school – Leaving Cert 3
Post Leaving Cert Course, Teagasc Cert/Diploma, Secretarial/ Technical Course, or Apprenticeship. 4
National Cert/Diploma or Cadetship 5
Primary Degree 6
Postgraduate Diploma or Masters Degree 7
Doctorate 8
Refused 9

SHOWCARD

Q.D8 Looking at this card, could you please tell me the letter that best describes the total income of all members of your household per year (whether from employment, pensions, state benefits, investments or any other source) **before** deduction of tax.
IF RESPONDENT DOES NOT WANT TO DISCLOSE THEIR INCOME REMIND THEM THAT IT WILL BE KEPT CONFIDENTIAL AND WILL BE USED ONLY FOR STATISTICAL ANALYSIS. CIRCLE ANNUAL OR MONTHLY ONLY.

(543-544)

	Approximate MONTHLY (Gross)	Approximate ANNUAL (Gross)	Code
A	Less than €150	Less than €1800	01
B	€150 to under €300	€1800 to under €3600	02
C	€300 to under €500	€3600 to under €6000	03
D	€500 to under €1000	€6000 to under €12000	04
E	€1000 to under €1500	€12000 to under €18000	05
F	€1500 to under €2000	€18000 to under €24000	06
G	€2000 to under €2500	€24000 to under €30000	07
H	€2500 to under €3000	€30000 to under €36000	08
I	€3000 to under €5000	€36000 to under €60000	09
J	€5000 to under €7500	€60000 to under €90000	10
K	€7500 to under €10000	€90000 to under €120000	11
L	€10000 or more	€120000 or more	12
	Refused	Refused	99

Q.D9 In which **county** do you live?

(545-546)

Cavan 01
Kildare 08
Louth 02
Meath 03
Offaly 09
Westmeath 04
Kilkenny 05
Tipperary 06
Waterford 07

(651-653)

Q.D9a What is the name of this townland?
Specify ________________ 997
Don't know 999

(547)

Q.D10 DAY OF INTERVIEW

Monday....................	1
Tuesday....................	2
Wednesday....................	3
Thursday....................	4
Friday....................	5
Saturday....................	6
Sunday....................	7

START TIME OF MAIN INTERVIEW (USE 24 HOUR CLOCK):
(e.g. 2pm = 14:00)

☐☐ : ☐☐

(548-549) (550-551)

END TIME OF MAIN INTERVIEW (USE 24 HOUR CLOCK):
(e.g. 2pm = 14:00)

☐☐ : ☐☐

(552-553) (554-555)

(Blank 556-600)
(Blank 641-650)

That is the end of the interview, thank you very much for your time.

I hereby declare that the interview was conducted according to the Market Research Code of Conduct.

RESPONDENT NAME:

____

RESPONDENT TELEPHONE NUMBER:

____

RESPONDENT ADDRESS:

____

____

RESPONDENT TOWNLAND:

____

INTERVIEWER SIGNATURE:

____

DATE OF INTERVIEW:

____

APPENDIX E

WALD TESTS OF RIVER ATTRIBUTES

Table E1: Wald tests of basic models coefficient equality

Boyne	MNL		NMNL		MMNL	
H_0:	Wald χ^2 test statistic	p-value	Wald χ^2 test statistic	p-value	Wald χ^2 test statistic	p-value
River Life Moderate = Good	2.541	0.110	2.968	0.084	5.997	0.014
Appearance Some improvement = A lot of improvement	8.790	0.003	8.061	0.004	9.977	0.001
Recreation More activities = All activities	1.239	0.265	1.415	0.234	3.060	0.080
Suir						
River Life Moderate = Good	3.684	0.054	10.121	0.001	0.346	0.556
Appearance Some improvement = A lot of improvement	6.647	0.009	0.558	0.454	0.950	0.329
Recreation More activities = All activities	1.687	0.193	0.401	0.526	0.562	0.453

Note: p-value less than 0.05 indicates a nonlinear effect

Table E2: Wald tests of extended models coefficient equality

Boyne	MNL		NMNL		MMNL	
H_0:	Wald χ^2 test statistic	p-value	Wald χ^2 test statistic	p-value	Wald χ^2 test statistic	p-value
River Life Moderate = Good	1.518	0.129	1.662	0.096	1.106	0.268
Appearance Some improvement = A lot of improvement	2.987	0.002	2.766	0.005	2.689	0.007
Recreation More activities = All activities	1.559	0.119	1.630	0.103	2.329	0.019
Suir						
River Life Moderate = Good	2.364	0.018	3.125	0.001	2.044	0.041
Appearance Some improvement = A lot of improvement	2.358	0.018	0.844	0.398	0.752	0.452
Recreation More activities = All activities	1.357	0.174	0.325	0.745	0.864	0.387

Note: p-value less than 0.05 indicates a nonlinear effect

APPENDIX F

ANALYSIS OF SECOND SET OF CARDS

Table F1: Analysis of second set of cards (overview)

	Boyne-MNL 1		Boyne-MNL 2		Suir-MNL 1		Suir-MNL 2		Boyne-MMNL		Suir-MMNL	
RL _G	-0.714	(-2.915)***	-0.957	(-4.61)***	0.542	(1.295)	-0.284	(-0.77)	-1.714	(-2.033)**	-5.622	(-1.894)*
RL _M	0.208	(1.431)	-0.137	(-1.07)	0.001	(0.004)	-0.792	(-3.76)***	0.108	(0.290)	2.251	(1.698)*
AP_A	1.313	(7.039)***	1.08	(7.01)***	-0.213	(-0.657)	-0.368	(-2.00)*	4.018	(4.796)***	-0.799	(-0.812)
AP_S	0.704	(4.279)***	0.427	(3.04)***	-0.024	(-0.085)	-0.447	(-2.37)**	1.994	(3.523)***	-2.363	(-2.058)**
RC _A	1.242	(5.438)***	1.21	(6.38)***	0.499	(1.733)*	0.755	(2.85)***	2.625	(3.619)***	1.309	(1.371)
RC _S	1.635	(9.099)***	1.50	(11.16)***	0.574	(2.321)**	-0.017	(-0.08)	3.375	(5.551)***	1.283	(1.467)
RB	-0.541	(-3.729)***	-0.793	(-6.14)***	-0.100	(-0.452)	-0.684	(-4.00)***	-0.788	(-2.502)**	0.004	(0.005)
R_Boyne	-0.796	(-3.153)***			-2.778	(-6.923)***			-1.938	(-3.189)**	-10.124	(-3.473)***
R_Suir	-1.444	(-5.680)***			-0.370	(-1.010)			-4.135	(-4.575)***	-4.344	(-2.409)**
R_Both	-0.536	(-2.354)**			-0.990	(-2.759)***			-0.965	(-1.745)*	-5.395	(-2.635)***
Cost	-0.004	(-1.637)	-0.001	(-0.82)	-0.037	(-6.137)***	-0.034	(-6.62)***	0.002	(0.291)	-0.092	(-4.127)***
St. Dev.												
RL _G									5.339	(3.930)***	10.993	(2.819)***
RL _M									2.116	(4.070)***	0.077	(0.126)
AP_A									2.843	(4.681)***	2.320	(2.252)**
AP_S									3.063	(4.530)***	4.788	(3.166)***
RC _A									2.243	(2.962)***	1.946	(1.631)
RC _S									2.023	(4.169)***	1.309	(1.928)*
RB									0.749	(1.719)*	2.215	(2.267)**
R_Boyne									0.881	(1.457)	5.021	(3.007)***
R_Suir									3.387	(4.195)***	7.598	(3.093)***
R_Both									1.606	(3.710)***	6.114	(3.683)***
LL	-768.72		-795.86		-408.24		-452.888		-689.94		-335.96	
χ^2	234.41		280.31		131.03		482.869		492.14		716.72	
Pseudo-R^2	0.132		0.150		0.138		0.348		0.262		0.516	
BIC	798.20		817.30		436.08		473.13		746.23		389.11	
Obs.	852		852		632		632		852		632	
# of resp.	213		213		158		158		213		158	

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%. RL = River Life, AP = Appearance, RC = Recreation, RB = River Bank, G=Good, M=Moderate, A=A lot of improvement, S=Some improvement.

Table F2: Analysis of second set of cards with interactions (MNL models)

	Boyne-1st specification[a]		Boyne-2nd specification[a]		Suir-1st specification[b]		Suir-2nd specification[b]	
RL_G*Boyne								
RL _M*Boyne	0.866	(2.300)***	0.013	(0.041)	0.939	(0.939)	0.780	(0.778)
AP_A*Boyne	0.883	(2.111)**	-0.204	(-0.512)	1.622	(1.828)*	1.461	(1.645)
AP _S*Boyne	-0.745	(-1.579)	-2.785	(-6.470)***	-3.636	(-3.339)***	-3.001	(-2.727)***
RC _A*Boyne	1.931	(3.445)***	2.801	(5.940)***	-3.924	(-2.429)**	-3.102	(-1.896)*
RC _S*Boyne	0.580	(1.410)	0.139	(0.343)	0.905	(0.982)	0.839	(0.911)
RB*Boyne	-0.565	(-1.192)	-0.240	(-0.659)	-3.930	(-4.679)***	-3.153	(-3.693)***
RL_G*Suir					0.123	(0.104)	-0.958	(-0.834)
RL _M*Suir	-1.592	(-1.717)*	-4.001	(-4.392)***	-0.908	(-1.653)*	-0.454	(-0.840)
AP_A*Suir	1.402	(1.757)*	2.132	(2.765)***	-0.257	(-0.684)	0.380	(1.027)
AP _S*Suir	2.251	(4.053)***	2.361	(4.119)***	0.442	(0.769)	0.706	(1.361)
RC _A*Suir	1.875	(1.576)	5.264	(4.235)***	0.892	(1.233)	0.390	(0.556)
RC _S*Suir	1.277	(1.576)	2.218	(2.799)***	0.569	(1.149)	0.579	(1.183)
RB* Suir	-1.685	(-1.981)**	-4.583	(-5.511)***	-0.388	(-0.778)	-0.205	(-0.423)
RL_G*Both	0.681	(1.387)			0.891	(1.400)		
RL _M*Both	0.572	(2.453)**			0.046	(0.151)		
AP_A*Both	0.962	(3.844)***			-1.846	(-3.858)***		
AP _S*Both	0.246	(1.035)			-1.368	(-3.727)***		
RC _A*Both	0.338	(0.950)			1.131	(2.380)**		
RC _S*Both	1.831	(8.244)***			0.619	(1.519)		
RB*Both	-0.751	(-4.153)***			-0.390	(-0.923)		
Cost	-0.016	(-4.563)***	-0.018	(-6.670)***	-0.043	(-6.112)***	-0.031	(-5.468)***
SQ			-1.636	(-11.235)***			0.784	(4.245)***
Diagnostics:								
LL	-738.07		-770.42		-398.23		-405.3615	
χ^2	295.70		230.40		151.06		136.80	
Pseudo-R^2	0.166		0.130		0.159		0.144	
BIC	791.68		807.94		451.38		443.33	
Correctly predicted	49%		46%		63%		63%	
Observations	852		852		632		632	
# of respondents	213		213		158		158	

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%. [a] River Life _G for Boyne and Suir from the second set of cards had to be omitted to avoid (almost) flat log-likelihood. [b] River Life _G for Boyne from the second set of cards had to be omitted to avoid (almost) flat log-likelihood.

Table F3: Analysis with both set of cards with interactions (MNL models)

	Boyne-1st specification[a]		Boyne-2nd specification[a]		Suir-1st specification[b]		Suir-2nd specification[b]	
RL_G*Boyne	0.546	(3.314)***	0.279	(1.799)*				
RL _M*Boyne	0.890	(6.382)***	0.483	(3.760)***	0.719	(0.718)	0.657	(0.656)
AP_A*Boyne	0.818	(7.042)***	0.130	(1.109)	1.497	(1.687)*	1.401	(1.581)
AP _S*Boyne	0.388	(3.202)***	-0.309	(-2.485)***	-3.803	(-3.471)***	-2.873	(-2.606)***
RC _A*Boyne	0.435	(3.241)***	0.332	(2.542)**	-3.705	(-2.291)**	-2.780	(1.712)*
RC _S*Boyne	0.269	(2.452)**	-0.059	(-0.558)	0.795	(0.864)	0.836	(0.909)
RB*Boyne	0.639	(7.520)***	0.219	(2.608)***	-3.902	(-4.692)***	-2.993	(-3.570)***
RL_G*Suir					-0.105	(-0.513)	0.151	(0.729)
RL _M*Suir	-1.693	(-1.990)**	-3.493	(-4.259)***	-0.030	(-0.223)	0.408	(2.711)***
AP_A*Suir	1.559	(2.171)**	1.852	(2.733)***	0.036	(0.254)	0.583	(3.796)***
AP _S*Suir	2.127	(4.847)***	2.207	(5.004)***	-0.068	(-0.360)	0.314	(1.633)
RC _A*Suir	2.388	(1.915)*	4.719	(4.027)***	-0.100	(-0.530)	-0.051	(-0.272)
RC _S*Suir	1.327	(1.797)*	2.153	(3.101)***	-0.522	(-3.267)***	-0.308	(-1.890)*
RB* Suir	-1.768	(-2.283)**	-4.231	(-5.713)***	-0.266	(-1.872)*	-0.030	(-0.212)
RL_G*Both	0.719	(1.727)*			0.389	(0.656)		
RL _M*Both	0.994	(5.159)***			0.015	(0.055)		
AP_A*Both	0.173	(2.468)**			-1.896	(-4.294)***		
AP _S*Both	0.173	(0.748)			-1.303	(-3.955)***		
RC _A*Both	0.982	(3.020)***			1.164	(2.612)***		
RC _S*Both	2.176	(11.182)***			0.113	(0.344)		
RB*Both	-0.911	(-5.248)***			-0.530	(-1.332)		
Cost	-0.021	(-9.836)***	-0.015	(-8.072)***	-0.029	(-8.684)***	-0.026	(-9.216)***
SQ			-1.210	(-11.705)***			0.969	(7.421)***
Diagnostics:								
LL	-1517.53		-1623.17		-957.89		-951.27	
χ^2	442.82		231.54		221.98		235.22	
Pseudo-R^2	0.127		0.06		0.103		0.110	

BIC	1573.82	1663.37	1011.04	989.23
Correctly predicted	47%	43%	55%	56%
Observations	1704	1704	1264	1264
# of respondents	213	213	158	158

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%. [a] River Life _G for Suir from the second set of cards had to be omitted to avoid (almost) flat log-likelihood. [b] River Life _G for Boyne from the second set of cards had to be omitted to avoid (almost) flat log-likelihood

Table F4: Analysis with both set of cards – Dummy nested specification (MNL models)

	Boyne-1st specification[a]		Boyne-2nd specification[a]		Suir-1st specification[b]		Suir-2nd specification[b]	
RL_G*Local River_set1	0.658	(3.646)***	0.570	(3.310)***	-0.080	(-0.355)	0.292	(1.247)
RL _M* Local River_set1	0.843	(5.661)***	0.546	(4.022)***	0.157	(0.965)	0.721	(3.958)***
AP_A* Local River _set1	0.851	(6.625)***	0.273	(1.997)**	0.166	(0.926)	0.568	(3.062)***
AP _S* Local River _set1	0.567	(4.322)***	0.084	(0.619)	-0.137	(-0.608)	0.071	(0.317)
RC _A* Local River _set1	0.360	(2.504)**	0.033	(0.229)	-0.108	(-0.509)	0.055	(0.262)
RC _S* Local River _set1	0.210	(1.824)*	-0.136	(-1.202)	-0.625	(-3.604)***	-0.321	(-1.792)*
RB* Local River_set1	0.667	(7.370)***	0.217	(2.289)**	-0.360	(-2.230)**	-0.202	(-1.231)
RL_G*B_set2								
RL _M*B_set2	0.914	(2.322)**	0.099	(0.294)	0.724	(0.721)	-1.274	(0.694)
AP_A* B_set2	1.066	(2.533)**	-0.206	(-0.525)	1.495	(1.684)*	1.399	(1.576)
AP _S* B_set2	-0.774	(-1.602)	-2.761	(-6.537)***	-3.813	(-3.473)***	-2.862	(-2.585)***
RC _A* B_set2	2.287	(4.099)***	2.933	(6.230)***	-3.719	(-2.296)**	-2.796	(-1.717)*
RC _S* B_set2	0.610	(1.471)	0.267	(0.668)	0.788	(0.856)	0.798	(0.867)
RB* B_set2	-0.713	(-1.391)	-0.302	(-0.810)	-3.900	(-4.695)***	-2.935	(-3.508)***
RL_G*S_set2					-0.887	(-0.801)	-1.274	(-1.159)
RL _M*S_set2	-1.688	(-1.831)*	-4.005	(-4.500)***	-1.150	(-2.129)*	-0.358	(-0.663)
AP_A*S_set2	1.575	(2.002)**	2.222	(2.939)***	-0.435	(-1.188)	0.507	(1.385)
AP _S*S_set2	2.396	(4.409)***	2.450	(4.380)***	-0.054	(-0.103)	0.702	(1.371)
RC _A*S_set2	1.953	(1.502)	5.314	(4.353)***	1.156	(1.619)	0.317	(0.453)
RC _S*S_set2	1.319	(1.632)	2.365	(3.032)***	0.469	(0.953)	0.504	(1.039)
RB*S_set2	-1.713	(-2.023)**	-4.639	(-5.706)	-0.242	(-0.492)	-0.113	(-0.237)
RL_G*Both_set2	1.223	(2.654)***			0.542	(0.900)		
RL _M*Both_set2	0.883	(4.298)***			0.045	(0.155)		
AP_A*Both_set2	0.755	(3.157)***			-1.750	(-3.953)***		
AP _S*Both_set2	0.197	(0.821)			-1.307	(-3.969)***		
RC _A*Both_set2	0.277	(0.772)			0.944	(2.100)**		
RC _S*Both_set2	2.056	(9.781)***			0.068	(0.205)		
RB*Both_set2	-0.772	(-4.219)***			-0.547	(-1.373)		
Cost	-0.022	(-9.552)***	-0.020	(-9.750)***	-0.029	(-8.146)***	-0.026	(-8.586)***
SQ			-1.364	(-12.076)***			0.998	(7.336)***
Diagnostics:								
LL	-1499.46		-1566.54		-950.33		-943.58	

χ^2	478.96	344.80	237.102	250.60
Pseudo-R^2	0.137	0.09	0.11	0.117
BIC	1571.83	1622.84	1021.20	999.26
Correctly predicted	48%	45%	56%	56%
Observations	1704	1704	1264	1264
# of respondents	213	213	158	158

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%. [a] River Life _G for Suir and Boyne from the second set of cards had to be omitted to avoid (almost) flat log-likelihood. [b] River Life _G for Boyne from the second set of cards had to be omitted to avoid (almost) flat log-likelihood

Table F5: Results for the stacked data sets after omitting the catchment variable from the second set

	Joint MNL_Boyne		Joint MNL_Suir		Joint MMNL_Boyne		Joint MMNL_Suir	
RL _G	0.282	(1.79)*	0.065	(0.39)	-0.186	(-0.40)	0.365	(0.65)
RL _M	0.632	(4.70)***	0.283	(2.09)**	1.73	(3.55)***	0.110	(0.29)
AP_A	0.981	(6.80)***	0.453	(3.09)***	3.31	(4.58)***	-0.314	(-0.78)
AP_S	0.552	(4.05)***	0.296	(2.04)**	1.14	(2.49)**	-0.253	(-0.74)
RC _A	0.700	(5.33)***	0.036	(0.27)	3.04	(4.28)***	0.319	(0.95)
RC _S	0.685	(6.43)***	-0.167	(-1.34)	2.83	(4.59)***	-0.079	(-0.26)
RB	0.566	(5.11)***	-0.070	(-0.71)	1.31	(2.91)***	-1.64	(-4.10)***
Cost	-0.015	(-5.39)***	-0.021	(-7.50)***	-0.021	(-2.79)**	-0.050	(-5.25)***
SQ	0.246	(1.36)	1.09	(6.12)***	1.43	(2.68)**	1.16	(3.17)***
St. Deviations								
RL _G					2.53	(2.88)***	1.41	(1.16)
RL _M					2.19	(3.81)***	2.73	(5.28)***
AP_A					3.64	(4.63)***	2.76	(4.09)***
AP_S					4.10	(4.81)***	1.88	(3.70)***
RC _A					3.78	(2.87)***	1.25	(2.05)**
RC _S					3.66	(2.87)***	0.979	(1.80)*
RB					4.12	(5.18)***	2.84	(5.61)***
Diagnostics:								
LL	-1636.95		-987.61		-1480.59		-880.19	
Pseudo-R^2	0.126		0.289		0.209		0.366	
χ^2	470.16		802.05		782.88		1016.903	
# of observations	1704		1264		1704		1264	
# of individuals	213		158 (316)		213 (426)		158 (316)	
	Scale=0.603, t-test=-4.92, p-value=0.00 Rob. t-test= 2.49, p-value=0.01		Scale=1.38, t-test=2.98, p-value=0.00 Rob. t-test= 1.91, p-value=0.06		Scale=0.39, t-test=6.71, p-value=0.00 Rob. t-test= 4.21, p-value=0.00		Scale=0.838, t-test=1.13, p-value=0.26 Rob. t-test= 0.83, p-value=0.40	
H_0: $\beta_{1\ model} = \beta_{2\ model} = \beta_{pooled}$	LR-test value of							

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%.

Table F6: Results for the stacked data sets keeping from the second set only improvements concerning the local river

	Joint MNL_Boyne		Joint MNL_Suir		Joint MMNL_Boyne		Joint MMNL_Suir	
RL _G*B	0.278	(1.51)	0.291	(1.26)	0.196	(0.45)	0.346	(0.68)
RL _M*B	0.396	(2.66)**	0.624	(2.97)***	0.817	(2.43)**	0.168	(0.34)
AP_A*B	0.420	(3.32)***	0.837	(4.68)***	0.972	(2.74)**	1.04	(2.21)**
AP_S*B	0.010	(0.08)	0.507	(2.61)**	-0.806	(-2.09)**	0.684	(1.47)
RC _A*B	0.341	(2.45)**	-0.037	(-0.20)	1.59	(3.36)***	-0.248	(-0.46)
RC _S*B	-0.022	(-0.20)	-0.229	(-1.27)	-0.120	(-0.37)	0.0482	(0.13)
RB*B	0.309	(3.38)***	0.074	(0.50)	0.612	(2.01)**	-1.51	(-2.78)**
Cost	-0.013	(-4.70)***	-0.026	(-7.67)***	-0.025	(-2.94)***	-0.063	(-5.24)***
SQ	-0.987	(-7.69)***	1.42	(6.34)***	-1.95	(-4.83)***	1.83	(4.91)***
St. Deviations								
RL _G					1.82	(1.49)	2.03	(2.68)**
RL _M					1.81	(3.04)***	4.49	(5.49)***
AP_A					2.18	(4.34)***	2.08	(3.35)***
AP_S					3.41	(5.19)***	1.19	(1.61)
RC _A					1.92	(1.49)	2.73	(3.31)***
RC _S					1.86	(3.45)***	1.13	(2.28)**
RB					3.73	(6.07)***	3.31	(5.07)***
Diagnostics:								
LL	-1685.71		-976.17		-1580.53		-876.50	
Pseudo-R^2	0.100		0.297		0.156		0.369	
χ^2	372.64		824.93		582.99		1024.29	
# of observations	1704		1264		1704		1264	
# of individuals	213		158 (316)		213		158 (316)	
Scale	Scale=0.671, t-test=2.85, p-value=0.00 Rob. t-test= 1.26, p-value=0.21		Scale=0.982, t-test=-0.14, p-value=0.89 Rob. t-test= 0.10, p-value=0.92		Scale=0.428, t-test=5.02, p-value=0.00 Rob. t-test= 1.97, p-value=0.05		Scale=0.606, t-test=3.52, p-value=0.00 Rob. t-test= 2.79, p-value=0.01	
H_0: $\beta_{1\ model}=\beta_{2\ model}=\beta_{pooled}$								

Notes: t-stats in parentheses. (*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%.