VALUING QUALITY IMPROVEMENTS IN ENVIRONMENTAL GOODS

A CASE STUDY FOR THE TICINO RIVER

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To my parents!

Abstract

Where prices are missing as an indicator of value, economic non-market valuation represents an important tool for efficient and transparent decision-making. Given that environmental goods and services are often priceless, environmental economists have a long history of applying valuation tools. Two prominent valuation approaches are the Contingent Valuation Method (*CVM*) and the Travel Cost Method (*TCM*). They have until recently been considered as competing valuation approaches. A main advantage of the *CVM* over the *TCM* is that it allows the net benefits of policies to be estimated without actually being implemented. However, this advantage comes at the cost of protest and strategic responses and other biases. On the other hand, the *TCM* has drawbacks in valuing environmental quality changes. Recent advances promise substantial improvements in the quality of economic analyses of environmental quality changes. One of them is the combination of revealed and stated preference data in order to estimate improvements in environmental quality.

This thesis focuses on the estimation of benefits from environmental quality improvement, illustrated with a water low flow enhancement in the Ticino River. Low flows in rivers are a major negative externality of hydropower energy production, affecting, among others, recreational uses of rivers. A low flow alleviation could therefore result in substantial welfare increases.

A Heckman sample selection model was used for model estimation in order to correct for sample selection bias. Quite significant annual increases in individual welfare resulted, confirming the importance of considering the recreational benefits in policy decisions. In fact, in taking decisions regarding a restoration of rivers for example through a low flow enhancement, it is important to take into account all the costs and benefits involved, both monetary and non-monetary. If, for example, benefits to recreational anglers, an important part of non-monetary benefits, were not included in a cost-benefit analysis, decision-making could seriously be biased to the detriment of the environment.

Key words: low flow alleviation, contingent valuation, strategic bias, Travel Cost Model, combined stated-revealed preference models, Heckman sample selection model

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Abbreviations

CBA - Cost-Benefit Analysis

HCS - Hicksian Compensating Surplus

HTCM – Hypothetical Travel Cost Model

MCS – Marshallian Consumer Surplus

CV/CVM - Contingent Valuation Method

ML - Maximum Likelihood

RP – Revealed Preference Data

RUM – Random Utility Model

SP – Stated Preference Data

TCM - Travel Cost Method

WTA - Willingness To Accept

WTP - Willingness To Pay

WPL – Water Protection Law

Preface

This doctoral thesis arose out of a project commissioned by the authorities of the Canton of Ticino, who were interested in gaining insights on the recreational benefits accruing to anglers from an enhancement of the water flow levels in the rivers of the Canton. Out of strong concern for the environment, during my economics studies I have become particularly interested in the application of economics to environmental issues. With this thesis, I have had the opportunity to apply textbook knowledge to a real-world problem. It has been an exciting, very intensive, stimulating and challenging time.

My thanks for intellectual support go to my supervisors, Prof. Dr. Massimo Filippini and Prof. Dr. Rico Maggi. Moreover, I would like to thank David Pearce, Professor at the University College London, and Brett Day from CSERGE for their assistance in analysing protest bids in Contingent Valuatio studies. A huge thank you also goes to my colleagues and friends at the University of Lugano, at the Federal Institute of Technology of Zurich, and at University College London. In particular, for their friendship and moral support I would like to thank: Rossana Galli, Gianluca Cassese, Federica De Rossa, Alessandro Cento, Diego Lunati, Ilaria Mosca, Simona Bolis, Cornelia Luchsinger, Eric Rayn, Cristina Sala, Nathalie Olsen and many more. Further, I wish to thank my parents for their constant presence and loving care.

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The usual disclaimers apply: all remaining errors are mine.

Lugano, April 2004 Loa Buchli

Chapter 1: Introduction

1.1 Problem and objectives

Hydropower is considered a clean way of producing electric energy, since no damaging air pollutants are generated. Nonetheless, hydropower has some important negative impacts on the environment. A major problem concerns low water flow levels (short "low flows") and artificial flow alterations in rivers, which are exploited by hydropower plants. This negatively affects water ecosystems and fish populations, as well as the attractiveness of the rivers for water-based recreational activities. Recreational anglers are particularly interested, since water scarcity causes the elimination of valuable habitat for various fish populations.

In Switzerland 60% of electricity is produced by hydropower. One of the main Cantons contributing is the Canton of Ticino, where rivers are more or less severely affected by low flows. Ignoring the opportunity costs of these negative effects might result in outcomes which are to the detriment of the environment and society as a whole. This has been recognised by the Federal Water Protection Law (*WPL*)[1]. This law aims at improving the quality of Swiss water bodies by providing the legal basis for cantonal regulatory measures when a careful analysis of costs and benefits justifies interventions.

Since water flow levels are not "normal" market goods with prices determined by demand and supply, it is not straightforward to gain information on the benefits expressed in monetary terms from an increase of flow levels. Under the heading of valuation, economists have developed several approaches to attributing value to environmental amenities.

The principal valuation methods can be divided into *stated preference methods* and *revealed preference approaches*. The usefulness and applicability of the single approaches depends fundamentally on the environmental amenity to be valued and on the objective of the valuation. When use values, such as recreation use, are the main component of the value of an environmental asset, revealed preference approaches such as the Travel Cost Model (*TCM*) can be applied. If non-use values (existence values, for example) are the focus of interest, stated preference methods such as the Contingent Valuation Method (*CVM*) have to be used, since revealed preference approaches are unable to assess non-use values.

The first application of these approaches referred to the valuation of a given natural site, not an environmental quality change. However, the valuation of quality changes became of greater policy-relevance owing to increasing environmental degradation. In existing environmental valuation literature, quality valuations are mostly carried out within the Contingent Valuation framework, since valuing quality changes increases theoretical, technical and practical challenges for the Travel Cost Method. Moreover, the Contingent Valuation Method allows the ex-ante estimation of the net benefits of policies, which are not actually implemented. Given that revealed preferences approaches rely on observed behaviour, it is not possible to value hypothetical situations. However, this advantage of the Contingent Valuation Method comes at the cost of possible protest and strategic responses. Recent methodological developments are more effective in valuing environmental quality changes than those used in the past. They basically rely on *combining revealed and stated preference* data.

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[1] *WPL* of the 24th January 1991, see Systematische Sammlung des Bundesrechts: www.admin.ch/ch/d/sr/814_20/index.html

This thesis illustrates and applies the *Hypothetical Travel Cost Model* (Layman et al., 1996), an interesting combination of revealed and stated preference data where behavioural data given current quality is supplemented by contingent behaviour data given a quality improvement. The appealing feature of this methodological approach is that it adopts the idea from the Contingent Valuation of explaining the link between the quality improvement program and the characteristics as perceived by individuals. Based on the illustration of the link, instead of soliciting individual's WTP, individuals are asked to state their intended behavioural response to the quality improvement.

The goals of the thesis are twofold:

From a *methodological* point of view,

- the Hypothetical Travel Cost Model is applied to the valuation of a low flow enhancement in the Ticino River;
- and the applicability of the Contingent Valuation is analysed with focus on the problem of protest responses.

From a *policy* point of view, the main interest lies in estimating some reference value of the recreational benefits from a low flow enhancement in the Ticino River. This helps answer the question if and how much, from a socio-economic view, it is worth to invest in measures to improve river quality.

1.2 Low flows in the rivers of the Canton of Ticino

Low water flow levels in Ticino's rivers have been in the political debate for quite a while in the Canton of Ticino.[2] The problem has arisen with the development of hydropower. In fact, Ticino's rivers have been exploited by hydropower plants since the beginning of the 20th century.[3] The growing demand for electricity led to a substantial growth of the sector between 1950 and 1970. This favoured the economic development of the peripheral and economically weak areas of the Canton and has provided the population with a secure and competitive supply of energy. Today, the Canton of Ticino is the third biggest contributor to the 60% of electricity produced by hydropower in Switzerland (after the alpine Cantons Wallis and the Grisons). Among the factors determining its importance are the alpine morphology of the Ticino territory, with its considerable variations in altitude, the richness of its hydrologic system and the substantial amount of yearly rainfall.

The Canton of Ticino nowadays has a total of 15 run-of-river plants and 14 storage plants. Figure 1 shows that these plants are highly concentrated on the rivers of the Sopraceneri area[4], the northern part of the territory. The Sopraceneri contains the most important rivers of the Canton of Ticino, the Ticino River, the Maggia River and the Verzasca River. The rivers of the Sottoceneri, substantially Vedeggio, Cassarate, Magliasina and Laveggio, are less exploited.[5]

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[2] The Canton of Ticino is the Italian-speaking part of Switzerland situated in the south-eastern part of Switzerland, bordering with Italy. With a population of 310'000, it is one of the more populous cantons of the Swiss Confederation (in 7th place out of the 26 cantons).

[3] The Canton has since 1894 been trustee of public waters and manages the use of waters through the distribution of licences.

[4] See Appendix 5 for the map of angling zones and Appendix 6 for the definition of areas.

[5] For a detailed presentation of the hydropower sector in the Canton Ticino see Martignoni & Barelli (1997).

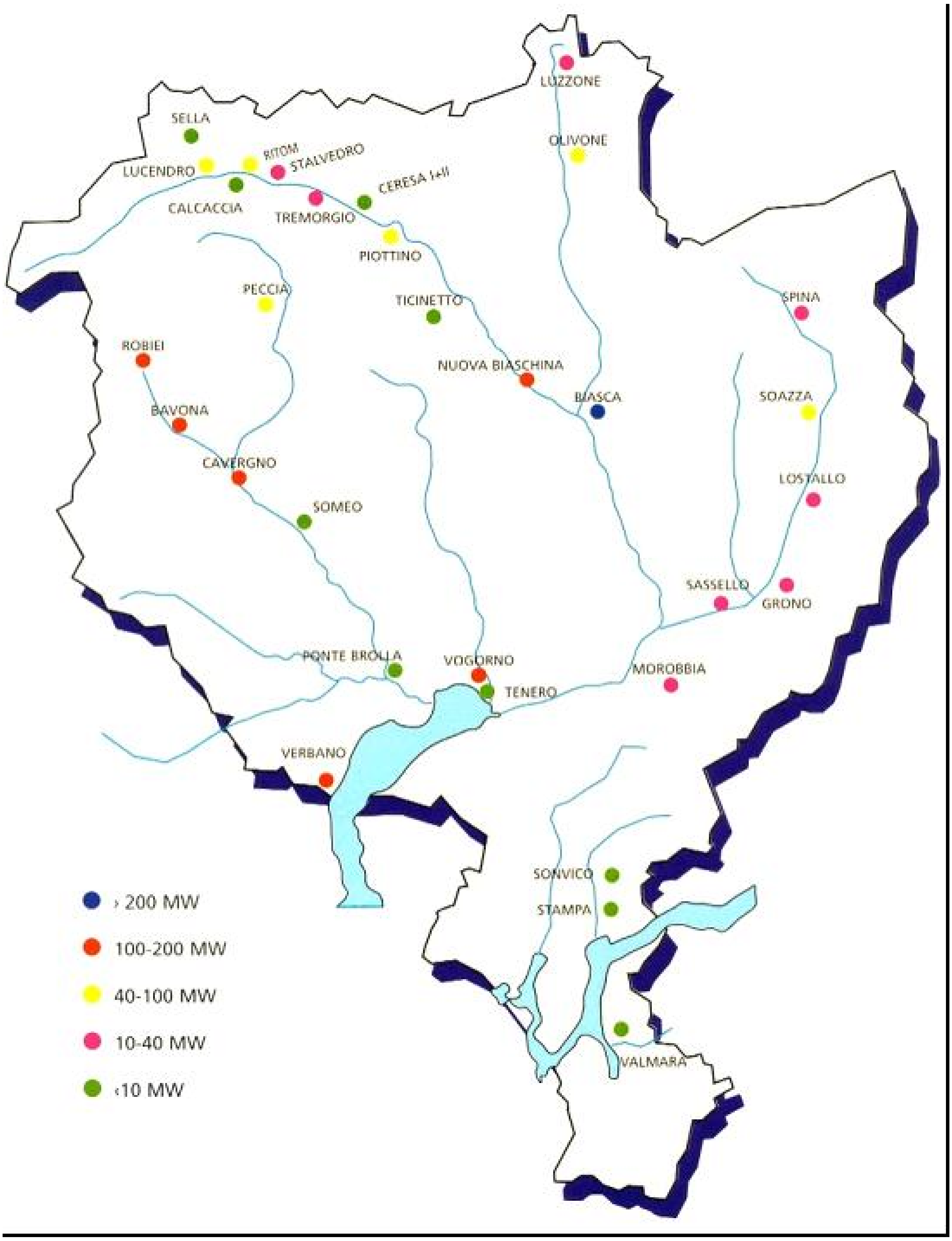

Figure 1 - Distribution of the hydropower plants in the Canton of Ticino and Mesolcina and Calanca valleys in the Canton of Grisons (hydropower plants with installed power higher than 300 kW)

Source: Martignoni & Barelli (1997)

The high density of hydropower plants and dams has made the problem of low flows acute and has triggered much public political discussion. In practice, flow regimes no longer depend on natural events such as rainfall, thaw or drought. This has caused a progressive and uninterrupted change of the ecological balance (Dipartimento del Territorio, 1990-97). Take as an example the Sopraceneri. Owing to the presence of a large number of hydropower plants, this region's water regime has undergone considerable modification. A closer look at the situation in the Maggia River, one of the most abundant fishing rivers of the Canton before the construction of the hydropower plants, illustrates the issue. Since low flows affect spawning and reproduction of fish stocks, strong water captures have resulted in a huge decrease of the fish population (Martini, 1999). Scientific research carried out on the Brenno River (Graia, 1994) analysed the potential effects of low flow enhancements on fish stocks and found evidence of substantial increases.

In general, the low flow problem is very marked in the Ticino River and the Maggia River, where the majority of hydropower plants and dams divert water from those rivers. Table 1 illustrates to what extent these rivers are burdened by the presence of water capture points of the various hydropower companies in Ticino, and how many of them are subject by licence to regulations regarding low flows. In fact, in only 25 water capture points are low flows regulated by the licences. Moreover, the inventory of the water abstraction points reveal that at the over 100 water abstraction points spread over the whole cantonal territory, on average 84% of the natural annual flow is withdrawn, with peaks of 100% in certain points. Out of 109 capture points, in only 5 cases is the water abstraction lower than 70%, with the lowest value being approx. 41% (Celio, 1998).

Table 1 - List of water abstraction points for hydropower generation purposes in the Sopraceneri area[6]

Enterprise	Exploited rivers	Water abstractions	
		Total	With low flow regulations
Società Elettrica Sopracenerina (SES)	Maggia & tributaries	3	3
	Ticino & tributaries	1	1
Azienda Elettrica Comunale di Airolo	Ticino & tributaries	4	2
Ferrovie Federali Svizzere	Ticino & tributaries	3	
Cooperativa Elettrica di Faido	Ticino & tributaries	2	1
Azienda Elettrica Comunale di Bellinzona	Morobbia	2	1
Aar e Ticino SA di Elettricità	Brenno/Reuss	12	
Hydro-Electra	Isorno & tributaries	1	1
Officine Idroelettriche della Maggia	Maggia & tributaries	26	6
	Ticino & tributaries	4	
Cooperativa Elettrica di Dalpe	Ticino & tributaries	1	1
Officine Idroelettriche di Blenio	Brenno & tributaries	25	5
Verzasca SA	Verzasca & tributaries	1	1
Azienda Elettrica Ticinese	Ticino & tributaries	17	3

In order to address the problem of environmental degradation due to hydropower generation, the Swiss legislation formulated the Federal Water Protection Law (*WPL*) dated 24th January 1991. This federal law aims at improving the quality of Swiss water bodies, providing the legal basis for cantonal regulatory measures regarding low flows when the involved interests justify

[6] See www.ti.ch/DT/DA/SPAA/argomenti/deflussi/ and Message 4972 of February 9, 2000, Dipartimento del territorio, Report of the Consiglio di Stato on the motion of March 8, 1999, concerning: "Organization of low flow control".

environmental policy action.[7] The implicit idea of the law is to solve the conflict of interest in water use. On one hand, direct economic interests are inherent to hydropower plants, which depend on capturing and deviating water in order to generate hydropower. Obviously, for the hydropower plants, a policy aiming at a low flow alleviation involves an increase in costs due to unexploited economies of scale and a decrease in revenue. This could seriously compromise the competitiveness of Swiss hydropower plants in an international setting and is (although Switzerland has no deregulated energy sector[8]) becoming more significant with deregulation tendencies in the EU leading to increased competition in electric power generation. In close relation to hydropower company interests are the fiscal interests of the State (water rental fees and taxes), and the public's interests in having a secure and relatively cheap energy supply without pollutant emissions. In fact, one could imagine the scenario of the closure of "clean" hydropower plants because they cannot compete. If hydropower electricity is substituted with more damaging energy production, this could lead to an even worse situation in terms of overall societal well-being.

On the other hand, there are also interests related to the environmental amenity "river". Low flows in rivers not only disturb the natural biological balance (natural habitat of fluvial fauna and flora), it also impacts on the natural appearance of the river and therefore substantially limits the attractiveness of those areas for recreational water-based activities (bathing, canoeing, boating, hiking, etc.) to the indigenous population and tourists. The demand for limiting alterations in water flows caused by the hydropower sector is particularly vociferous from recreational anglers.

In fact, a large part of the value of low flow enhancement accrues to recreational users, anglers in particular. This becomes clear when considering that low flows and artificial flow alterations deriving from hydropower plants have a substantial impact on fish population. Hence, there is a clear trade-off between recreational angling and hydropower water abstraction. Finding a balanced solution to this trade-off is a significant challenge to policy-makers concerned with the allocation of water to various users. Since, as recognised by the *WPL*, at the heart of good policymaking stands sound appraisal, a robust valuation of impacts in money terms improves the quality and transparency of policy decision, particularly in view of the relicensing processes for hydropower plants.

This study concentrates on the benefit estimation for *recreational anglers*, representing a lower bound of the total benefits associated to a low flow enhancement to be included in policy-makers' assessments for optimal lines of action.

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[7] Art. 31 of the law fixes the indispensable low flow for the biological integrity of water streams; Art. 33 WPL transfers to the cantonal authority the task of taking measures to increase low flows in cases where a careful analysis of costs and benefits justifies interventions in this sense. In the wake of this law, hydropower plants are obliged to let a certain minimal flow run down the river. However, these legal provisions are only applied in the case of new licenses (construction of new plants) or when the authorization of already existing plants expire. In the meantime (from 2007), existing hydropower plants are obliged to put into action measures to restore residual flows, if the river conditions require immediate action (SAEFL, 2002).

[8] On 22nd September 2002, the Swiss population rejected a federal law (Energiemarktgesetz, EMG) to deregulate the Swiss energy sector.

1.3 Structure of the thesis

The thesis is structured in six chapters. Following this introductory first chapter, where the goals of the thesis and the issue of low flows in Ticino are illustrated, chapter 2 presents the fundamental theoretical basis of the various approaches to valuation. The focus of chapter 3 is on the presentation of three methodological approaches to value quality improvements of environmental amenities. Two frequently used techniques are the Travel Cost Model and the Contingent Valuation Approach. The third approach basically relies on combining the first two approaches. Chapter 4 presents the issue of protest bids often encountered in Contingent Valuation studies. This analysis highlights one reason for applying the Hypothetical Travel Cost Model for the valuation of a low flow alleviation in the Ticino River presented in chapter 5. The implementation of the empirical model will be illustrated and the results will be presented for the Ticino River, which is particularly affected by low flows. Chapter 6 presents some conclusions.

Chapter 2: The value of environmental quality

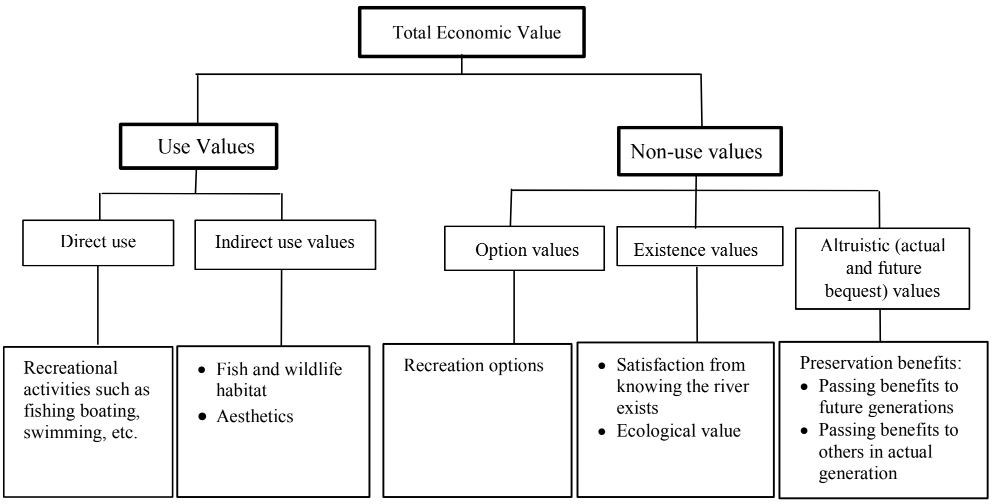
Although there seems to be general agreement over the fact that the natural environment is valuable, there is no common consensus on the nature of its value and on the possibilities of measuring it: neo-classical economists link the value of a good to the utility it provides. In this completely anthropocentric (i.e. human centred) view, the environment has an instrumental value, whose worth is gauged to the extent that individuals hold preferences for it. Environmentalists, on the other hand, tend to claim that nature has non-anthropocentric intrinsic values, i.e. nature has values "in itself". Given that intrinsic values are independent of human preferences, they cannot be encompassed by the neoclassical approaches to economic valuation.

Before introducing the neo-classical valuation approaches in chapter 3, the notion of "economic value" will be illustrated in section 2.1 for the case of a free-flowing river. Section 2.2 aims at specifying the link between welfare measures and the value of an environmental amenity. Section 2.3 presents the exact hicksian welfare measures derived from individual demand functions, while section 2.4 presents the Marshallian Consumer Surplus, usually applied as an approximation.

2.1 Value components of environmental amenities

The economic value of a natural river's services can be split into use and non-use values, as depicted in Figure 2. *Use values* refer to the benefits an individual receives from the *direct* or *indirect* use of the amenity. They are derived for example from the use of recreational services natural rivers provide. It is obvious that if there is little water in the river, the recreational use value of the river will be small, since angling, boating and other water-based recreation activities will be limited. *Indirect uses* are those uses for which a value is attributed in terms of services the river provides, such as a habitat for fish populations.

Figure 2 - Taxonomy of types of economic value



Source: Figure adapted after Bateman et al. (2002)

Non-use values (or passive use values) can be split in three main non-use components: *existence value, option value*, and *bequest values*. Non-use values are not related to the actual use of water.

Rather, *existence value* represents the willingness to pay for the knowledge that the river is protected even though no recreational use is contemplated. *Option value* (*OV*) arises only when there is incomplete knowledge of future conditions. It is a kind of insurance premium people are willing to pay to retain the option of possible future (recreational) use. In its calculation, risk and uncertainty have to be taken into account. *Actual and future altruistic value* (bequest value) is distinct from option value because it does not preserve an individual's option to use the river. Rather, it arises when the individual is concerned that it should be available to others in the current generation. When the concern is that the next and future generations should have the option to make use of the river, the value is called bequest value.

The total economic value (*TEV*) of the river (or any environmental amenity in general) is a combination of all the different use and non-use values.

2.2 Demand as expression of individual preferences

The key implication of the notion of economic value in the neo-classical view is that it is a preference-based concept, that is, the value depends on human preferences. Preferences can be made explicit by observing the demand. Demand is the result of a maximisation process, where individuals choose the consumption bundle, which maximises their utility, subject to their budget constraints. Hence, what people are willing to spend to satisfy their preferences is assumed to reflect the value. It is thus possible to derive information on the value of a given good or service from the demand for it (Bateman et al., 2002).

Environmental goods and services often do not have an explicit market demand, given their public good character. This however does not mean that they have no value. If individuals hold preferences for environmental quality, a simplified utility function can be written as[9]:

$$u(x,q) \tag{2.1}$$

where x represents the private good and q reflects the environmental quality. Individuals freely vary their consumption of the private market good x but q is exogenous to them. This reflects an important characteristic of many environmental amenities, i.e. that they are available only in fixed unalterable quantities (Freeman, 2003).

Then, conditional on the exogenous quality q, the individual is supposed to choose the consumption plan regarding x, which provides him with the highest possible level of utility u given a budget constraint. That is:

$$\text{Maximise } u(x,q) \text{ with respect to } x \tag{2.2}$$

given the budget constraint $px \leq y$, where p represents the market price of the private good x and y is the individual's disposable income, and given the environmental quality level $q=q^*$.

The maximising procedure (2.2) yields a set of conditional ordinary or Marshallian demand functions $x(p,y,q)$ [10]. Substituting them back into the utility function in equation (2.1), yields a set of conditional indirect utility functions

[9] Individual's preferences are assumed to be well-behaved, i.e. they are adequately comprehensive, stable and coherent. *Comprehensive* means that individuals must be able to make meaningful preference comparisons. *Stable* means that preferences must not vary arbitrarily over time, and that different theoretically valid methods of eliciting a person's preferences should yield the same results. *Coherent* means that the preferences that are elicited for any person must be internally consistent (Bateman et al., 2002).

$$v(p, y, q) \tag{2.3}$$

describing the maximum utility that can be achieved for a given set of prices and income, given *q*. The term *conditional* refers to the fact that these functions are conditional to the imposed *q*.

Inverting the conditional indirect utility function (2.3) to obtain the value of *y* which solves the equation $v(p, y, q) = u$ yields the conditional expenditure function

$$m(p, q, u) \tag{2.4}$$

representing the minimum expenditure necessary to achieve utility level *u*, given prices *p* and environmental quality *q*. The expenditure function can also be obtained as the result of expenditure minimisation subject to the attainment of minimum utility. The solution to the minimisation problem is the hicksian demand function[11] of prices and utility (for details see for example Braden & Kolstad, 1991).

2.3 Hicksian welfare measures for environmental quality changes

On this basis, it is now possible to derive hicksian welfare measures (see for example Johansson, 1987; or Braden & Kolstad, 1991). The value of an environmental quality change is measured by the amount of money required to make consumers indifferent to either having or not having the quality change.

Depending on the distribution of property rights, the welfare change is represented either by the Compensating Surplus (*CS*) or the Equivalent Surplus (*ES*).

Formally, (see for example Herriges & Kling, 1999):

$$CS=m(p^0,q^0,u^0)-m(p^0,q^1,u^0) \tag{2.5}$$

and

$$ES=m(p^0,q^1,u^1)-m(p^0,q^0,u^1) \tag{2.6}$$

where *m* stands for the expenditure function, p^0 is the current vector of prices, u^0 and u^1 are the reference levels of utility and the utility associated to a quality improvement, respectively, and q^0 and q^1 is the environmental amenity before and after a quality change.[12]

Equation (2.5) states that the *compensating surplus (CS)* is the change in income from the original income level that keeps the consumer at the original utility level u^0 given the new quality level q^1 of the environmental good. Hence, this is the correct measure when individuals hold property rights for the original utility level u^0, associated to the actual situation.

The *equivalent surplus* (*ES*) (2.6) is the change in income from the original income level that is required for the consumer to obtain the new utility level u^1 with the original quality q^0 of the

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[10] Marshallian demand functions are also termed uncompensated demand functions, because as quality changes, income is not adjusted to compensate for the resulting change in utility (see Braden & Kolstad, 1991).

[11] The hicksian demand function is also called compensated demand, since as environmental quality changes, income is adjusted to maintain utility constant.

[12] *CS* and *ES* can be equivalently expressed in terms of the indirect utility function (see for example Freeman, 2003). This presentation has been omitted for the sake of brevity.

environmental good[13]. This measure assumes that individuals hold the property rights for the new quality level.

The choice between *CS* and *ES* depends on the assignment of property rights. This is summarised in Table 2. Compensating measures (*CS*) apply if individuals have the right to status quo, i.e. q^0. It measures the willingness to pay (*WTP*) compensation for a higher quality and a willingness to accept (*WTA*) compensation for remaining at the current quality state. If, on the other hand individuals hold property rights for the new quality q^1 and consequently for new utility level u^1, the correct means of measuring the welfare effects is the Equivalent Surplus (*ES*). If q^1 represents an improvement with respect to q^0, *ES* corresponds to the willingness to accept (*WTA*) compensation to forego the improvement they had the right to. If on the other hand q^1 stands for a lower quality level than q^0, *ES* measures the *WTP* to forego the deteriorated situation individuals had property rights for.

Table 2 - Monetary measures for environmental quality changes

	CS (property right for u^0)	ES (property right for u^1)
Improvement	WTP for the change occurring	WTA compensation for the change not occurring
Deterioration	WTA compensation for the change occurring	WTP for the change not to occur

Source: Perman et al. (1999)

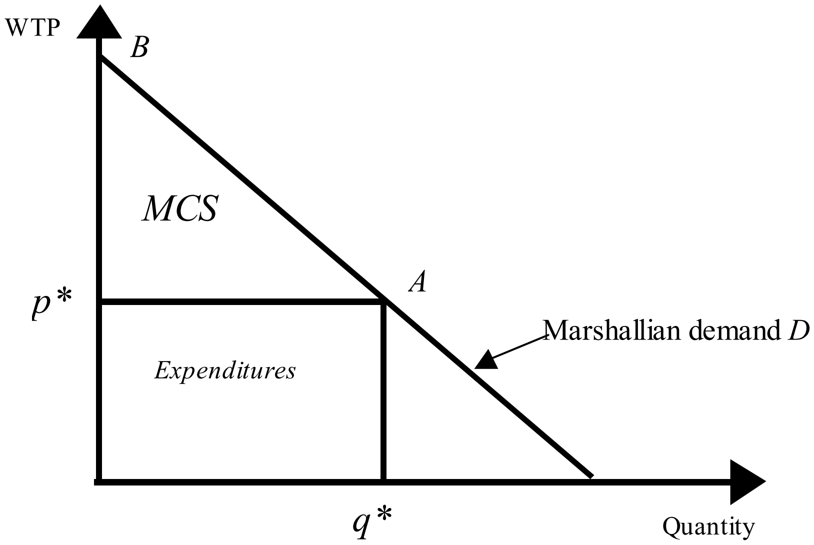
2.4 Marshallian Consumer Surplus

A critical feature of these hicksian welfare measures is that they are a function of utility and thus not directly observable. However, hicksian welfare measures can be calculated from the expenditure function obtained by integrating the estimated marshallian demand function (Hausman, 1981). Given that this is not very straightforward (particularly for censored models, as discussed by Hellerstein, 1992a) and implies some important problems for the valuation of a quality change as discussed by Bockstael et al. (1991), in practice the hicksian welfare measures are often approximated by the marshallian Consumer Surplus.

The marshallian Consumer Surplus (*MCS*) can be derived from the marshallian demand function (*D*), relating prices and marginal quantity increases, as depicted in Figure 3. Every point on the demand curve (*D*) shows how much an individual would be willing to pay for the last (marginal) unit, given income. The *MCS* is given by the difference between the price the consumer would be willing to pay and the price he actually pays p^* (see for example Varian, 1999). This corresponds to the area delimited by p^*AB.

[13] CS is positive for a desirable quality increase and is the maximum amount an individual is WTP to bring about this increase.

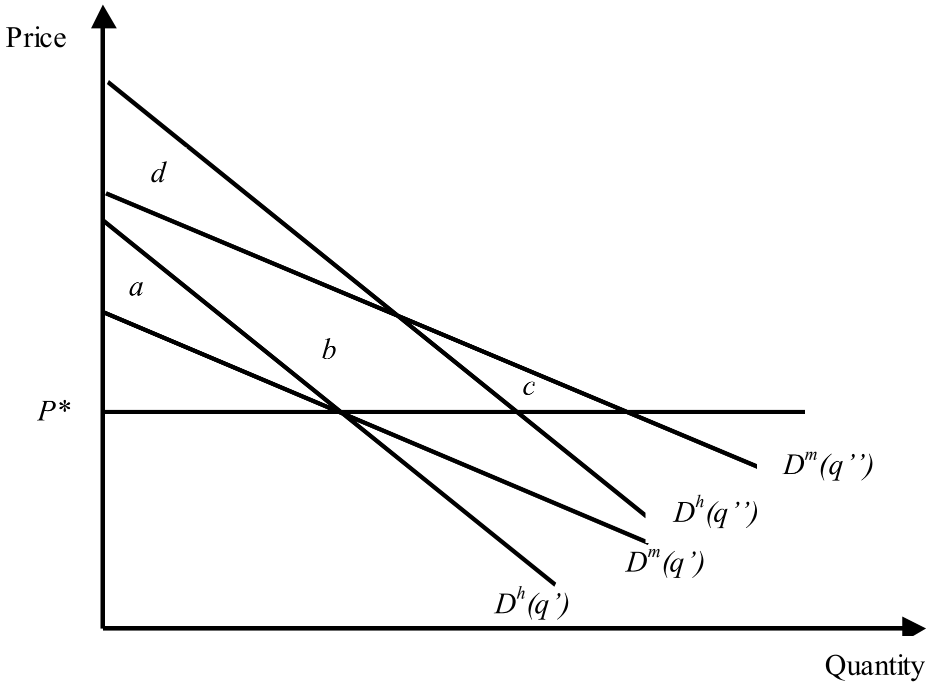
Figure 3 - Individual demand curve and Consumer Surplus



However, the question of whether *MCS* is a good approximation of the hicksian welfare measures has generated a considerable amount of literature. An important and often cited contribution is Willig's article (1976) showing that the size of error involved in using *MCS* will depend on the size of the income effect for the commodity of concern. The reason is that hicksian demand functions compensate for the income effect, whereas marshallian demand functions do not. Hence, where income effects are believed to be small, the approximation seems to be reasonable. When income elasticity of demand for the good in question is zero, the welfare measures collapse to one. For an illustrative discussion of the relative errors, see Perman et al. (1999).

Bockstael & McConnell (1993) have, however, shown that while for price changes statements of the size and direction of error from approximating hicksian welfare measures by the marshallian Consumer Surplus can be made, this is not possible in the valuation of quantity or quality changes. Yet quality changes are of much policy-relevance in the case of environmental amenities. Applying the *MCS* here yields a measure for which nothing can be said about the size and direction of the error. This can be illustrated graphically (Freeman, 2003) in Figure 4, where a quality improvement is depicted.

Figure 4 – Approximating benefits using Marshallian demand curves



The compensated hicksian demand curves for the two levels of quality q are denoted as $D^h(q')$ and $D^h(q'')$, and the compensating surplus for a quality improvement is measured by the area $b+d$. The ordinary marshallian demand curves are denoted by $D^m(q')$ and $D^m(q'')$. Observe that at the market price of p^*, the increase in q causes the ordinary demand curve to shift out farther to the right than the compensated demand curve. This is because with the ordinary demand curve, there is no compensating reduction in income to hold utility constant. Taking areas between the ordinary demand curves would yield a consumer's surplus measure of $a+b+c$. The percentage error arising when the consumer's surplus measure is used to approximate the compensating surplus is (see Freeman, 2003):

$$\%error = \frac{a+c-d}{b+d} \tag{2.7}$$

This error may be positive, negative, or zero. Thus, the practice of using ordinary demand curves to estimate welfare changes can lead to errors of unknown sign and magnitude.

Fortunately, many recreational problems can be expected to have small income effects. The difference between the hicksian and marshallian welfare measures is, therefore, unlikely to be very large (Bockstael et al., 1991; Bockstael & McConnell, 1993), and the application in this study of the marshallian CS as a welfare measure of the quality change does not warrant further investigation. The empirical results presented in chapter 5 will sustain the hypothesis that income has no impact on the demand for recreational angling.

Chapter 3: Non-market valuation techniques for valuing environmental quality

The goal of the first valuation studies reported in the literature was to measure the willingness to pay for the availability of an environmental amenity. But with the growing awareness of the degradation of the natural environment, the valuation of *quality* became increasingly important.

Economists started devising preference revelation methods for environmental amenities some fifty years ago. Hotelling suggested in 1949 using travel costs to determine the demand for recreation. Since then, the economic valuation literature has considerably grown and is now very extensive. The policy relevance of having information on the value of environmental quality has led researchers to place greater importance to addressing the issues related to the valuation of quality changes.

This chapter focuses on some methodological aspects of estimating the benefits deriving from environmental quality improvements.[14] It first classifies the different approaches on the basis of the nature of the empirical data (section 3.1). It then gives some insights in both revealed (section 3.2) and stated preference methods (section 3.3) and ends with an illustration of combining revealed and stated preference data in order to assess quality changes (section 3.4).

3.1 The nature of data

The methodological approaches to the valuation of quality changes in environmental amenities can be differentiated by the nature of empirical data they are based on. Basically, data are either revealed or stated:

- ***Revealed Preference Data*** (*RP*) is data on actual behaviour or choices made in observable situations. If the observed *RP* data has a substitute or complementary relationship with the environmental amenity, individual's preferences for environmental goods and hence their *use* values can be derived.

- ***Stated Preference Data*** (*SP*) is any data obtained as "individual responses to contingent circumstances posited in an artificially structured market" (Seller et al., 1985). Hence the source of the data is individual's responses to hypothetical questions revealing information about preferences and values. With *SP* data, it is possible to estimate both *use* and *non-use* values.

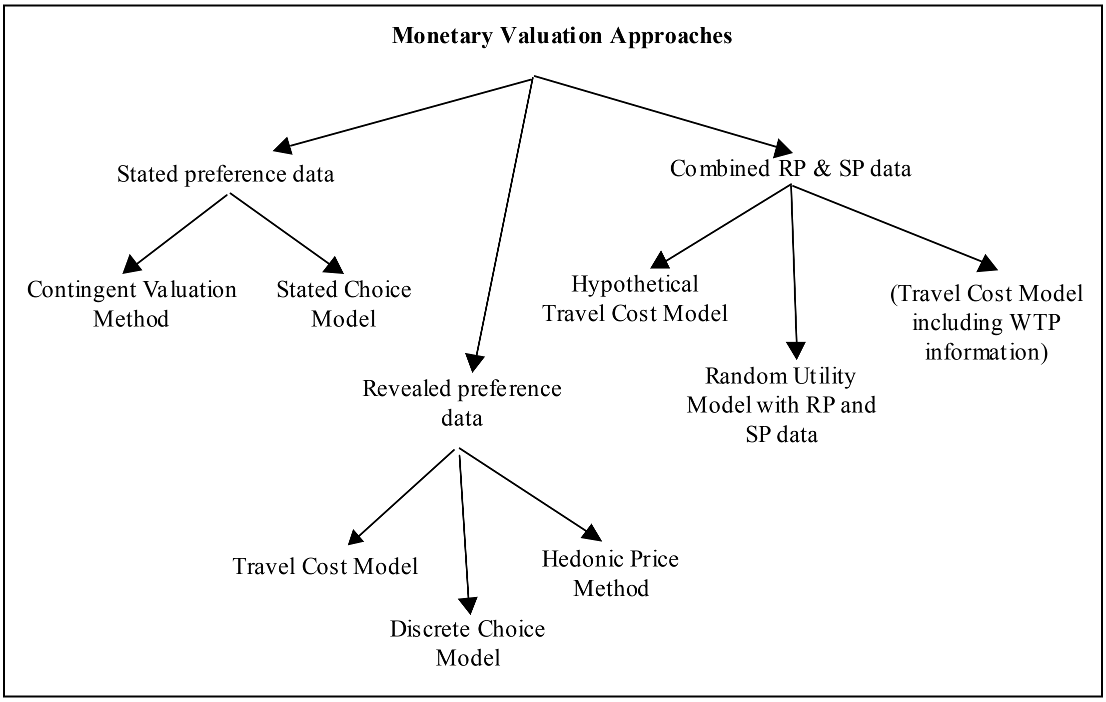
Based on these types of data, the valuation approaches differ as outlined in Figure 5. Three types of approaches can be distinguished: revealed preference approaches, stated preference approaches and approaches combining *RP* and *SP* data. The main of the *stated preference approaches* is the Contingent Valuation Method (*CVM*), where individuals are asked to state their Willingness to Pay (*WTP*) or Willingness To Accept (*WTA*) compensation. Alternatively, in the Stated Choice Model, individuals have to state their choices from a set of alternatives in a hypothetical setting. The information on the value is obtained by analysing the marginal rates of substitution between any pair of attributes that differentiate the alternatives. For a more detailed presentation, see Freeman (2003).

[14] Given that this discussion is standard literature, this short presentation of the underlying theoretical body is problem-oriented. That is, the presentation will be focused and restricted to what is relevant to the valuation of a low flow enhancement in Ticino's rivers with the Travel Cost Model.

Approaches, which rely on *RP* data are commonly termed *revealed preference approaches*. Three general approaches can be distinguished (Bockstael et al., 1987), as depicted in Figure 5: (1) the Travel Cost Model, which derives values from observed recreational behaviour, (2) the discrete choice model, which derives information on preferences from analysing the choices between different alternatives, analogously to the Stated Choice Model, with the difference that here the choices are effectively observed and not contingent on a hypothetical situation, and (3) the Hedonic Price Method, which draws information on the value of local environmental quality from price differences in the housing market. For the valuation of quality attributes of recreational sites, this method has been modified into a hedonic Travel Cost Model, which estimates the value of site characteristics directly from (recreationally related) demands for particular characteristics, rather than through the demand for recreational trips to sites (Bockstael et al., 1987).

Figure 5 depicts a third type of approaches, relying on a combination of *RP* and *SP* data. Combining data sources for valuing environmental amenities is becoming a frequent practice in environmental economics, mirroring earlier trends in marketing and transport studies (see, for example, Ben-Akiva & Morikawa, 1990). It aims at overcoming the limits revealed and stated approaches face when applied singularly. A detailed discussion will follow in section 3.4. Here, the main strategies of combining revealed and stated preference data are mentioned: (1) actual trip data combined with hypothetical trip data given an environmental quality improvement (Hypothetical Travel Cost Model - for applications, see Layman et al., 1996; Whitehead et al., 2000); (2) actual choice data combined with hypothetical choice data in a discrete choice Random Utility Model framework (see for example Adamowicz et al., 1997); (3) the combination of travel cost data with *WTP* Contingent Valuation data (for applications see Cameron, 1992; Huang et al., 1997; Kling, 1997).

Figure 5 - Monetary valuation approaches



The choice among contending methods for obtaining information on preferences regarding environmental amenities depends on the question to be answered, the nature of the good and the value component to be analysed (use and non-use values), the availability of data and the credibility of the restrictions necessary to recover information about preferences.

However, some general considerations can be made on the choice between *RP* and *SP* data. Although economists tend to prefer revealed preference approaches over the more controversial stated preference methods, in existing environmental valuation literature there seems to be far more Contingent Valuation studies than revealed preference analyses. This can partly be explained by the applicability of the revealed preference approaches restricted to use-values and the problems they face in valuing environmental quality changes. In fact, behavioural methods are limited to problems where behavioural responses to environmental quality changes can be observed. The most difficult problem in using behavioural models to value environmental quality changes lies perhaps in finding a link between the environmental quality change and the environmental characteristic perceived and valued by the individual. More details on this in section 3.2.

However, a very important issue of the *CVM* is its potential for strategic behaviour. Since public goods are provided anyway, individuals need not reveal their preferences for those goods. If they are asked to, they tend to state biased preferences due to strategic motivations: understating preferences pays if consumers will be asked to contribute to the provision of the public good. Overstating preferences occurs when there is no effective payment (free-rider). Strategic behaviour is even more important in situations where a public good is shared between two or more contending groups. For instance, the water of a river can be used by the hydropower industry, anglers and tourists. In this situation, as we will describe empirically in Chapter 4, the probability of observing strategic behaviour is very high.

As regards the choice between the Travel Cost Model and a discrete choice random utility model, the following observations can be made: When the focus of interest lies on the value of improvements, rather than the value of site attributes, and when it is believed that most of the effects of a change in environmental quality come about as a change in the total number of visits to all sites in the area, rather than a re-allocation of visits across sites, then the Travel Cost Model is a more appropriate choice of approach than a Random Utility site choice model (Garrod & Willis, 1999, Hanley et al., 2003).

3.2. Revealed Preferences: Recreation Demand Models

Revealed preference approaches try to infer demand patterns for environmental goods or services by observing market transactions for related private goods, which are linked to the environmental amenity. The degree to which inferences about the benefits of increasing quality q of the environmental amenity can be drawn from market observations depends on the way in which q enters individual utility functions (Freeman, 2003):

- Quality q can affect individual's utility by producing utility indirectly as a **factor input in the production of a marketed good** that yields utility. When q is a factor of production, changes in q lead to changes in production costs, which in turn affect the price and quantity of output. The benefits of changes in q can be inferred from these changes in observable market data.

- Quality *q* can affect individual's utility by being an **input in the household production** of utility-yielding commodities. Hence, individual's utility function contains the commodities *z* and *q* is an input for the production of *z*.
- Quality *q* can affect individual's utility by producing utility directly if *q* is an **argument in an individual's utility function**.

3.2.1. Weak complementarity

We concentrate here on the last case where *q* affects individual's utility directly. This in fact best reflects the situation, which will be analysed in chapter 5. A low flow enhancement in Ticino's rivers has a direct impact on anglers' utility. Low flows have a detrimental effect on fish stocks and hence on catch rates. The better the quality, the higher the utility of an angling trip, given that catch rates is a determining factor of the utility deriving from recreational angling activity. Hence there exists a complementary relationship between quality and angling trips.

Individual demand for environmental quality can then be derived from maximising individual utility subject to a budget constraint, or, dual to this, from minimising expenditures such that a minimum utility level is attained. The solution to the first is the marshallian demand curve $x^m(p,y,q)$, where the angling trips are a function of expenditures, income and quality. The solution to the second yields the hicksian demand with utility constant $x^h(p,u,q)$.

Note that *q* is exogenously given. Suppose then that the enjoyment of the trips *x* increase with an increase in quality and that an increase in *q* boosts the number of recreational trips taken. In this case, and under a condition called weak complementarity, it is possible to identify a measure of the value of a change in q that is based on the demand for the market good (Freeman, 2003).

There is weak complementarity between the market good, *x*, and the environmental quality, *q*, if a change in the environmental quality has no welfare effect on the individual, unless he consumes the private good[15] (see for example Van Kooten & Bulte, 2000):

$$\frac{\partial U}{\partial q} = 0 \big| x = 0 \tag{3.1}$$

In order for consumption of *x* to be zero, *x* must be a non-essential good. A good is non-essential if there exists a choke price, which drives demand to zero.

Hence, demand curves can be used to value site quality if it is weakly complementary to the demand for site visits, specifically, if (a) there is a choke price above which site visits are zero, (b) the marginal utility of site quality is zero if the site is not visited.

3.2.2. The Travel Cost Model of Recreation Demand

An illustration of the general principle of the valuation of one good through the demand of a second complementary good is given by the Travel Cost Model. The basic idea behind the TCM is very simple and intuitive. Assuming that the "quality" is weakly complementary to recreation trips, it is possible to retrieve information on the recreational value of a site through observing recreational behaviour. The expenditures an individual incurs for travelling to a single non-priced recreation site are viewed as an implicit price for the site's service. Recreational site users are assumed to adjust their trips to the site based on this implicit price.

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[15] An important implication that follows is that increases in the environmental quality need not be compensated unless the environmental amenity is not consumed.

For the formal basis of the model, let us look at a model of an individual's choice of the number of visits to make to a recreation site. For simplicity, assume that there is only one site available and that all trips have the same duration. Assume also that the individual's utility depends on the total time spent at the site, the quality of the site, and the quantity of a numeraire. With the duration of a visit fixed, the time on site can be represented by the number of trips. The individual solves the following utility maximisation problem (Freeman, 2003):

$$\max_{x} u(z, x, q) \tag{3.2}$$

subject to the budget constraint:

$$M + p_w \cdot t_w = z + c \cdot x \tag{3.3}$$

and the time constraint which indicates that both travel to the site and time spent on the site take time away from other activities:

$$t^* = t_w + (t_1 + t_2)x \tag{3.4}$$

where

z = quantity of the numeraire whose price is 1
x = number of visits to the recreation site
q = environmental quality at the site
M = exogenous income
p_w = wage rate
c = monetary cost of a trip
t^* = total discretionary time
t_w = hours worked
t_1 = round-trip travel time
t_2 = time spent on site

Remember that q is exogenous to individuals. Remember moreover the assumption of x and q being complements, implying that the number of visits will be an increasing function of the site's environmental quality.

Substituting the time constraint (3.4) into the income constraint (3.3) yields:

$$y = M + p_w \cdot t^* = z + p_r \cdot x \tag{3.5}$$

where p_r is the full price of a visit given by:

$$p_r = c + p_w (t_1 + t_2)$$

The full price of a trip has two components: the monetary costs of trips and the time costs. The monetary cost of a trip c is given by the entrance fee which could be zero, and the monetary costs of travel, that is the per km-costs multiplied by the distance to the site. The time costs consist of the time costs of travel to the site and the cost of time spent at the site. The two time costs are valued at the wage rate p_w. This relies on the assumption that individuals are free to choose the number of hours worked at a given wage rate, and that this wage governs the trade-off between work and leisure (Freeman, 2003). Time spent producing a recreational experience is not available for work to produce income. This leads naturally to the idea that time spent travelling should be valued using the cost of not working (Perman et al., 1999).[16]

Maximising the utility function (3.2) subject to the time and budget constraint (3.5) yields the individual's demand function for visits:

$$x = x(p_r, y, q) \tag{3.6}$$

where x stands for the marshallian demand function, specified as a function of the full price for travelling to the site, income, and the site's quality. Given data on visiting rates, travel costs can be used to estimate the coefficient on p_r in a travel cost-visit rate function (Freeman, 2003).

3.2.3. Valuing site benefits with the Travel Cost Model

In principle, with a diversity of locations for recreational users visiting a given site, there is sufficient information to measure the demand for the site's services (Smith et al., 1983). Relating revealed trips and trip costs, the *TCM* estimates the marshallian demand function for the recreation site. Thus, the marshallian *CS* for the environmental site under analysis can be expressed as the integral of the recreation demand function as follows:

$$CS = \int_{TCmean}^{TCchoke} trips(tc, y)dtc \tag{3.7}$$

where *trips* indicates the marshallian demand function, specified as a function of travel costs and other trip-determining factors, such as socio-economic (income, age, gender) and taste variables. TC_{mean} is the mean travel cost anglers incur to reach angling sites and TC_{choke} represents the maximum travel cost, which drives recreation demand to zero.

The marshallian *CS* value can be interpreted as the loss of benefits due to the closure of the site. This single site model can hence be used to measure the economic value of access. Note however that for the valuation of a single site, quality is the same for all individuals. This precludes observation of any variation in the level of quality. Hence, it is not possible to value changes in the quality of the site, an issue of particular policy-relevance. The past decade has seen intensive work by environmental economists with a view to adapting recreational demand models to value environmental quality improvements. The main approaches are presented in the following section.

3.2.4. Revealed preference approaches for valuing environmental quality improvements

Following Bockstael & McConnell (1999), there are basically three lines of research which can potentially address the quality valuation task: (1) multi-site Travel Cost Models; (2) hedonic price models; and (3) random utility models. Table 3 presents some empirical studies applying these approaches.

[16] Given the assumption that individuals are free to choose the hours they work at a given wage, the individual maximizes utility by allocating time among alternative activities to equate the marginal values of time in these activities with the wage rate. Thus the wage rate can be taken as an indicator of the shadow value or marginal opportunity cost of time (Freeman, 2003).

Table 3 - Revealed preferences benefit estimation of quality improvements in water bodies

Study	Goal of study	Estimator
Multi-site Travel Cost Models		
Vaughan, Russel (1982)	Value of a recreational fishing day differentiated by fish species sought	Generalised Least Squares (GLS)
Smith & Desvousges (1985)	Valuing recreational benefits of improved water quality	Two-step estimation procedure: First step: ML correcting for truncation and censoring Second step: GLS
Hedonic Travel Cost Model		
Brown & Mendelsohn (1984)	Analysis of the value of quality characteristics (congestion, scenery, fish density) for steelhead fishermen	OLS
Pendleton & Mendelsohn (1998)	Valuation of the impact of global warming on freshwater sport fishing	OLS
Random Utility Models (RUM)		
Pendleton & Mendelsohn (1998)	Valuation of the impact of global warming on freshwater sport fishing	Multinomial Logit
Caulkins, Bishop, Bowes (1986)	Lake water quality improvement	Multinomial Logit
Hausman, Leonard, McFadden (1995)	Estimation of welfare losses suffered by recreational users due to the Exxon Valdez oil spill	Combined discrete choice (multinomial logit and nested multinomial logit) and count data (fixed effects count) model
Train (1998)	Recreational fishing demand accounting for taste differences over people	Generalised logit model

In general terms, the difficulty of revealed preference approaches aiming at valuing environmental quality changes consists in specifying a model that incorporates variation in quality, so that behavioural responses to quality can be estimated.

Multi-site Travel Cost Models include variation in quality by treating a number of sites with different quality as a single site. The advantage of this data pooling over a number of sites is that, remaining within the construct of a single equation model, it is comparatively easy to estimate. The disadvantage lies in the fact that it is difficult to hold other important factors constant in order to avoid omitted variable bias (Bockstael & McConnell, 1999). Holding factors constant implies that all determining quality elements have to be adequately taken into account. However, the meaningful definition of variables capturing quality often proves difficult if not impossible (see also section 3.2.5). Moreover, a considerable number of sites need to be considered in order to obtain enough variation in the quality variable.

An important limitation of the pooling strategy is its implication that the coefficients in the demand equation are the same for all sites (Kling, 1988a). A more sophisticated version of the *TCM* which explicitly incorporates the effects of quality in the demand system without imposing constant demand parameters for all sites is the *varying-parameter model*. This multiple-site modelling approach proposed by Vaughan & Russell (1982) and applied by others (Smith et al., 1983a; Smith & Desvousges, 1985) consists in regressing trips to each site on travel costs and income and other socio-economic variables, as represented in equation (3.8), and using the travel cost coefficients from these regressions as a new dependent variable which will be regressed on the quality characteristics of the sites, see equations (3.9).

$$t_{si} = \beta_{s0} + \beta_{s1} X_{si1} + \ldots + \beta_{sK} X_{siK} + \varepsilon_{si} \qquad (3.8)$$

$$
\begin{aligned}
\beta_{s0} &= \gamma_{00} + \gamma_{01} Z_{s1} + ... + \gamma_{0L} Z_{sL} + u_{si} \\
\beta_{s1} &= \gamma_{10} + \gamma_{11} Z_{s1} + ... + \gamma_{0L} Z_{sL} + u_{s0} \\
&.... \\
&.... \\
\beta_{sK} &= \gamma_{00} + \gamma_{k1} Z_{s1} + ... + \gamma_{0L} Z_{sL} + u_{sK}
\end{aligned}
\tag{3.9}
$$

where

t_{si} = individual's *i* number of trips to site *s*

X_{sik} = first-step explanatory variables for site *s* including travel costs, per capita income, etc; $k = 1...K$

Z_{sl} = second-step explanatory variables including various measures of site characteristics which are invariant at a given site

β_{sk} = first-step parameters to be estimated which vary across sites

γ_{kl} = second-step parameters to be estimated which are invariant across sites

ε, u = stochastic disturbances

This extension of the traditional Travel Cost Model allows for a valuation of changes in site attributes.

Another way of valuing quality attributes of a recreational site is the *Hedonic Travel Cost Model* (Brown & Mendelsohn, 1984; Englin & Mendelsohn, 1991; Bockstael et al., 1987).[17] The idea of the model is that the extra cost necessary to travel to a better site reflects the value of the superior quality of that site. The model consists of two stages. In the first step, shadow prices are estimated for the characteristics that differentiate the recreational sites. The shadow prices are obtained through the estimation of a hedonic price function, which regresses an individual's travel costs on the site characteristics:

$$
tc_{is} = f(z_s) \tag{3.10}
$$

where tc_{is} stands for the price an individual *i* has to incur in order to reach the recreation site *s* and z_s is a bundle of characteristics characterising site *s*.

In order to develop welfare measures for marginal quality changes, a second step is needed. Marginal value functions for quality characteristics are estimated by regressing the hedonic prices of the attributes derived from the first step on the level of the quality characteristics at the relevant sites together with other individual related variables such as for example, socio-economic variables and recreational trip data. Unfortunately, there are important and complex econometric issues in the estimation of this inverse demand function (see for example Palmquist, 1999). This is one reason why the hedonic travel cost is not frequently used. Moreover, in contrast to the models of recreational behaviour such as the Travel Cost Model and discrete choice models, the hedonic travel cost model treats quality as a decision variable, where quality is purchased at higher costs. Hence, as argued by Bockstael et al. (1987) a question such as "what is a public action worth which improves water quality?" makes little sense. Additionally, the demand functions are associated with characteristics and not sites, and thus it

[17] The hedonic Travel Cost Model is inspired by the Hedonic Price Method (HPM) which has been used to estimate the impact of different environmental characteristics on rental or house prices. The differences in prices of similar apartments located in areas with different environmental characteristics (noise, air quality, parks etc.) allow for an estimation of the value of those environmental characteristics to the tenant. There are many applications in the literature, see for example Zabel & Kiel (2000), Chattopadhyay (1999), Baranzini & Ramirez (2001).

seems particularly difficult to assess the value of a site specific change in quality (Bockstael et al., 1987)

A further way of valuing environmental quality is given by *Random Utility Models (RUM)* (see for example Bennett & Blamey, 2001, for a general introduction). They are an appealing alternative in economic valuation given the inherent discrete nature of recreation demand decisions. In fact, Random Utility Models (*RUMs*) have a somewhat different logic than do recreational demand models. They do not look at how much an individual spends in monetary and non-monetary terms for having a particular environmental service in order to measure the welfare they derive from it. *RUMs* assume that a choice is the result of a comparison between the different utilities implied in the choices. The value of site attributes is then derived by analysing individual's site choices out of many recreational sites, as a function of the attributes of the sites.

More formally, the random utility framework consists in assuming that the utility maximising individual faces a choice among discrete, quality-differentiated site alternatives and that the individual *n* chooses the alternative *i* with the highest utility *U* (see for example Adamowicz et al., 1997). The utility consists of a systematic component *V*, which is expressed as a function of the quality characteristics and the characteristics of the decision-maker, and a random component ε:

$$U_{in} = V_{in} + \varepsilon_{in} \tag{3.11}$$

That is, an individual's indirect utility function is assumed to be stochastic, with an error term that varies across individuals. The error term reflects the analyst's inability to measure or identify all possible factors that can influence a respondent's decision (Garrod & Willis, 1999).

Given the utilities for the different alternatives, site *i* is chosen over site *j* if $U_{in} > U_{jn}$ for individual *n*. That is, the individual compares the utilities of the different alternatives. Then, the probability of individual *n* choosing alternative *i* is

$$\Pr\{i\} = \Pr\{V_{in} + \varepsilon_{in} \geq V_{jn} + \varepsilon_{jn}; \forall_j \in C_n\} \tag{3.12}$$

Depending on the assumption on the nature of the random term, i.e. normal or Gumbel, probit or logit specifications are used respectively in the estimation of the Random Utility models.

An important advantage of the Random Utility framework is that, contrary to the Travel Cost Model, it is able to deal with multiple sites with different environmental attributes. When valuation questions address the subject of "substitutability" among sites, these models seem to offer a very appealing approach. However, *RUM*s are not the appropriate choice when a quality change is assumed to imply a change in total recreation trips rather than a re-allocation of these trips across sites. When a policy action which is supposed to affect both site choices and the number of overall trips has to be valued, the procedure is to append a censored or count-type traditional Travel Cost Model to the *RUM* (Hausman et al., 1995; Caulkins et al., 1986). Note, however, that welfare calculations in these models are very cumbersome and require complex mathematical manipulations of the estimated coefficients in order to value non-marginal changes in attributes (Pendleton & Mendelsohn, 2000).

3.2.5. Limits to revealed preference approaches

Even if it was possible to specify a revealed preference model incorporating quality variation so that behavioural responses to quality changes can be estimated, there are some important issues which prevent the successful valuation of an environmental quality improvement with the previously presented approaches:

(1) ***Observability*** of behaviour or choices. A hypothetical low flow enhancement at a particular recreation site has typically no behavioural "footprints". Hence, revealed preference techniques which rely on the observability of behaviour or choices are not applicable;

(2) ***Definition of quality:*** It might be difficult to define what determines quality and to measure appropriate indicators. A river has many quality attributes, such as water quality (including temperature, velocity, flow level etc.), fish stocks, landscape character etc.

(3) ***Variation in the quality variable***. It often proves difficult to observe enough variation in the quality variable in order to have meaningful and statistically significant answers from the econometric model. Moreover, quality might be correlated with other non-policy site characteristics, so that it is difficult to estimate the effect of interest (Loomis, 1997). It might also be the case that actual quality variations might not cover the range of policy interest, such as in the case of a hypothetical quality improvement. In both cases, revealed preference approaches cannot be applied for quality valuation.

(4) ***Individual perceptions***: Although some quality attributes of the river, such as temperature or water velocity, could be incorporated quite easily as quality indicators, what is actually measured may not correspond with what people perceive as important. In fact, Adamowicz et al. (1997) find that perceptions and actual measures are not always strongly correlated.

Given these issues, the revealed preference data approaches which manage to include quality characteristics, such as the varying parameters approach which pools data (Vaughan & Russel, 1982; Smith & Desvousges, 1985), the hedonic *TCM* (Brown & Mendelsohn, 1984; Englin & Mendelsohn, 1991), or the random utility model applied to revealed data (Caulkins et al., 1986; Hausman et al., 1995; Train, 1998) may still fail to value quality changes owing to the difficulty of observing behaviour, problems of measurement and insufficient/poor variability in the quality variable. However, even if quality is successfully included in the model, there might be no (strong) correlation between the objective quality and how people perceive the situation. This represents a problem if it is, as is plausible, assumed that perceptions determine individual behaviour more than objective facts.

3.3. Stated preferences: The Contingent Valuation Method

Where revealed preference methods fail, stated preference approaches might be an alternative for valuing the welfare effects of environmental quality changes. The most prominent among them is the Contingent Valuation Method (*CVM*), an important part of the valuation tool kit, yielding directly hicksian welfare measures. In a typical *CV* survey (see for example Mitchell & Carson, 1989; Bateman & Willis, 1999), respondents are asked to consider a scenario describing for example a hypothetical environmental quality change. Upon this description, they are asked to state the value they would place on the specified change. Depending on the distribution of property rights, people are asked either about their Willingness To Pay (*WTP*) or Willingness To Accept (*WTA*) (see section 2.3). One of the main difficulties of this approach consists in the construction of the scenario. The scenario must provide respondents all relevant information, a cumbersome task for situations unfamiliar to the respondents. But there is also the risk to present information which induce individuals to give biased responses. The scenario must be constructed such as to avoid all possible biases. For a detailed discussion on the issue, see Mitchell & Carson, 1989.

One of the main advantages of the Contingent Valuation Method is its broad applicability. In fact, the Travel Cost Model cannot be used for as wide a variety of valuation tasks as can the Contingent Valuation: for example, the *TCM* is not able to evaluate future use values and, most importantly, non-use values such as existence value. However, professional opinion regarding the Contingent Valuation Method is divided (Hanemann, 1994; Diamond & Hausman, 1994; Portney, 1994). The main point of disagreement regards the validity (i.e. the extent to which the *WTP* measures the true value) and reliability (i.e. consistency of *WTP* of over time and space) of *CV* results. Some anomalies occurring in empirical work have spawned substantial mistrust (Hoehn & Randall, 1987). For example (1) most *CVM* studies have the problem of a proportion of zero bids for the *WTP* question, (2) Willingness To Accept (*WTA*) question formats can lead to unexpectedly large valuations, (3) estimates of *WTP* and *WTA* may diverge to a greater extent than economic theory would predict.

There exists an extensive literature testing different design and implementation approaches in order to reduce these anomalies. An important portion of research has focused on finding and testing question formats that will solicit unbiased answers, which accurately portray value (see for example Watts Reaves et al., 1999). In fact, the hypothetical nature of the question has led some researchers to advance the critique that a hypothetical question will yield a hypothetical answer (Balistreri et al., 2001; Boyle & Bergstrom, 1999). The main formats for eliciting *WTP/WTA* values are (see for example Freeman, 2003) the open-ended question (*OE*), with the payment card (*PC*) as a variation, and the dichotomous choice[18] (*DC*). In the *OE* format of questioning, a respondent is simply asked how much he or she would be willing to pay for an improvement in the quality of some environmental good. The major problem of *OE* questions is that it confronts people with an unfamiliar problem, raising doubts on the reliability and validity of the answers. With the *PC* format, respondents are presented with a range of values for the environmental change. The payment card format reduces some of the difficulty of trying to assign a monetary value with no guidance. The *DC* format is even more similar to the market situation: respondents are presented with a money amount and asked if they would agree to contribute with the given amount to an environmental improvement. Each individual's response to the question "would you be willing to pay *X* SFr." reveals either an upper bound (for a no) and a lower bound (for a yes) on the relevant welfare measure. However, the disadvantage of *DC* is that it needs a high number of observations since it makes a relatively inefficient use of the sample (Freeman, 2003).

With open-ended responses, an estimate of the total value of the welfare change for the population from which the sample is drawn can be obtained in a straightforward manner by multiplying the sample mean of the *WTP/WTA* responses by the total population. The data can also be used to obtain a bid function, B^*, for a given change in q. For this purpose, the responses are regressed on income, y, and other socio-economic characteristics, s, which are supposed to affect an individual's valuation (see Freeman, 2003):

$$B^* = B^*(y, s) \tag{3.13}$$

[18] The dichotomous choice method is also referred to as the closed-ended, take-it-or-leave-it, discrete choice, or referendum method (Watts Reaves et al., 1999)

Data on the characteristics of the relevant population can subsequently be used to calculate B^* for every member of the population.

The analysis of dichotomous choice responses is not as straightforward as the open-ended *WTP* data. In fact, the conversion into a monetary measure of yes or no responses to a discrete choice question requires the use of an explicit utility theoretic model of choice. See Freeman for a detailed illustration (Freeman, 2003).

Chapter 4 deals with the issue of protest bidding which might invalidate *CV* results. This issue will be illustrated with the analysis of *WTP* responses for a river flow enhancement.

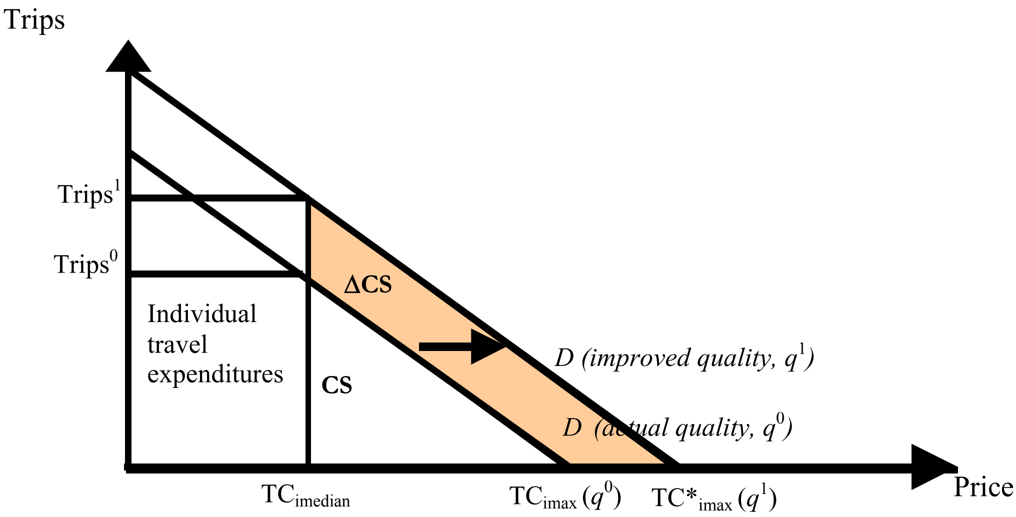
3.4. Combining revealed and stated behaviour data for valuing non-marginal quality improvements

As already mentioned in section 3.1, combining revealed and stated preference data for estimating recreation demand has until recently been a relatively unexplored tool in valuation literature (Haab & McConnell, 2002). It views stated and revealed preference data not as competing, but as complementary information sources. Combining data can help overcome the respective limitations of the revealed and stated approaches. The appeal of combining *recreation behaviour* data lies in the fact that it allows the benefit estimation of a non-marginal quality change in the travel cost framework with relatively easy to interpret results. Non-marginal changes in environmental amenities often prove to be more relevant for economic policy than marginal values (Herriges & Kling, 1999).

Take a non-marginal increase in the Ticino River's water flow levels from q^0 to q^1. Assume that this low flow enhancement is perceived by individuals as enhanced attractiveness. In fact, a low flow alleviation has a substantial impact on fish population and therefore on anglers' expected catch rates. Moreover, a low flow enhancement will generally improve the river from an aesthetic point of view. If recreation trips are related to the river's quality as a weak complement, the quality improvement will lead to a rightward-shift of the recreational demand as illustrated in Figure 6[19]. The demand curve *D(actual quality)* represents the individual demand for a river with acute low flows (quality q^0), while the shifted curve *D(improved quality)* illustrates the demand with enhanced flows (quality improvement to q^1). Hence, with constant travel costs and all else equal (ceteris paribus), a quality improvement translates into an increase in the number of recreational trips from $Trips^0$ to $Trips^1$. The marshallian Consumer Surplus (*CS*) associated to the quality improvement is then represented by the shaded area ΔCS.

[19] Note that the axes in Figure 6 have been inverted compared to the traditional way of illustration, with trips on the vertical and prices (travel costs) on the horizontal axis. This is done for illustrative reasons and has no impact on the conclusions.

Figure 6 - Increase in Consumer Surplus from a quality improvement



Legend:

CS: welfare measure (marshallian Consumer Surplus) of site with initial quality level, q^0

ΔCS: welfare measure of quality improvement from q^0 to q^1

CS+ *ΔCS*: welfare measure of site with improved quality, q^1

In order to calculate *ΔCS*, the rightward shift of the recreational demand has to be econometrically estimated. Given that the quality improvement is hypothetical, it is essential to obtain valid information on the increased demand (Huang et al., 1997). There is typically no data on observed behaviour available. However, the shift can be modelled by augmenting the revealed data for the actual situation with stated contingent behaviour data for the improved situation. Data on contingent behaviour is obtained by constructing a hypothetical scenario of an environmental quality improvement and by asking individuals to state their intended trips given the improvement at the site under analysis.

The combination of revealed and stated preference data not only enables us to *identify individuals' preferences* (Ben-Akiva & Morikawa, 1990) for a hypothetical quality improvement where no behaviour is observable, but also where insufficient variation in the quality variable or multicollinearity in site characteristics prevent meaningful estimation of the effect of quality on the recreation demand by strategically designing the quality levels in the contingent behaviour portion of the survey (Adamowicz et al, 1994). It further allows for the valuation of quality for single sites, where there is typically no variation in the quality variable. Pooling data from sites with differing quality might provide information on the benefits from quality improvements, though at the cost of assuming that the relevant population has the same preference structure for all sites and with the risk of multi-site bias, i.e. some bias caused by the difficulty of holding all other relevant factors constant.

Recreational preference identification for hypothetical scenarios is also possible in the Contingent Valuation framework. The advantage of the combined approach over the *CVM* is that the hypothetical scenario is based on an actual situation. This considerably simplifies the contingent market and helps reduce the hypothetical bias: respondents have already thought about their decisions under actual conditions prior to answering questions about hypothetical behaviour. Moreover, in contrast to traditional *CVM* models, it is not necessary to explicitly state price and payment vehicles, given that angling trips involve direct expenditures. This reduces the possibility for protest and strategic behaviour, and increases the confidence in contingent behaviour data. The consistency of the intended behaviour can moreover be tested in the combined approach by comparing actual and intended behaviour in the actual situation (Whitehead et al., 2000).

Another key feature of the combined estimation method is the improved *statistical efficiency* of parameter estimates over the use of either data source separately (Ben-Akiva & Morikawa, 1990), as more information on the same set of underlying preferences is employed in constructing the estimates (Huang et al., 1997). This improves the identification of influential parameters.

In sum, the combination of stated and revealed data should yield a more comprehensive picture of preferences. The existing empirical findings are rather encouraging since they suggest that substantial gains can be made from combining data sources. Chapter 5 examines in more detail the application of the combined approach to the valuation of a non-marginal hypothetical low flow enhancement in the Ticino River.

Chapter 4: Protest Bids in Contingent Valuation Studies

The Contingent Valuation Approach can typically be applied to the estimation of benefits deriving from a hypothetical environmental quality improvement. As stated before, its defining feature is that it asks people directly about their Willingness To Pay (Willingness to Accept) for an environmental quality change.

Contingent Valuation studies often face a substantial amount of zero bids, or zero willingness to pay amounts. This presents a problem if there is reason to believe that the zero *WTP* bids do not reflect true individual *WTP*. In fact, one of the fundamental assumptions of *CV* is that the value people are willing to pay for a change in the environmental quality reflects how they value the change (Mitchell & Carson, 1989). Obviously, if this assumption is violated, *WTP* values derived from *CV* cannot automatically be interpreted as the value of the change in the environmental amenity. A high portion of zero bids is an indicator of a likely problem of untruthful preference revelation.

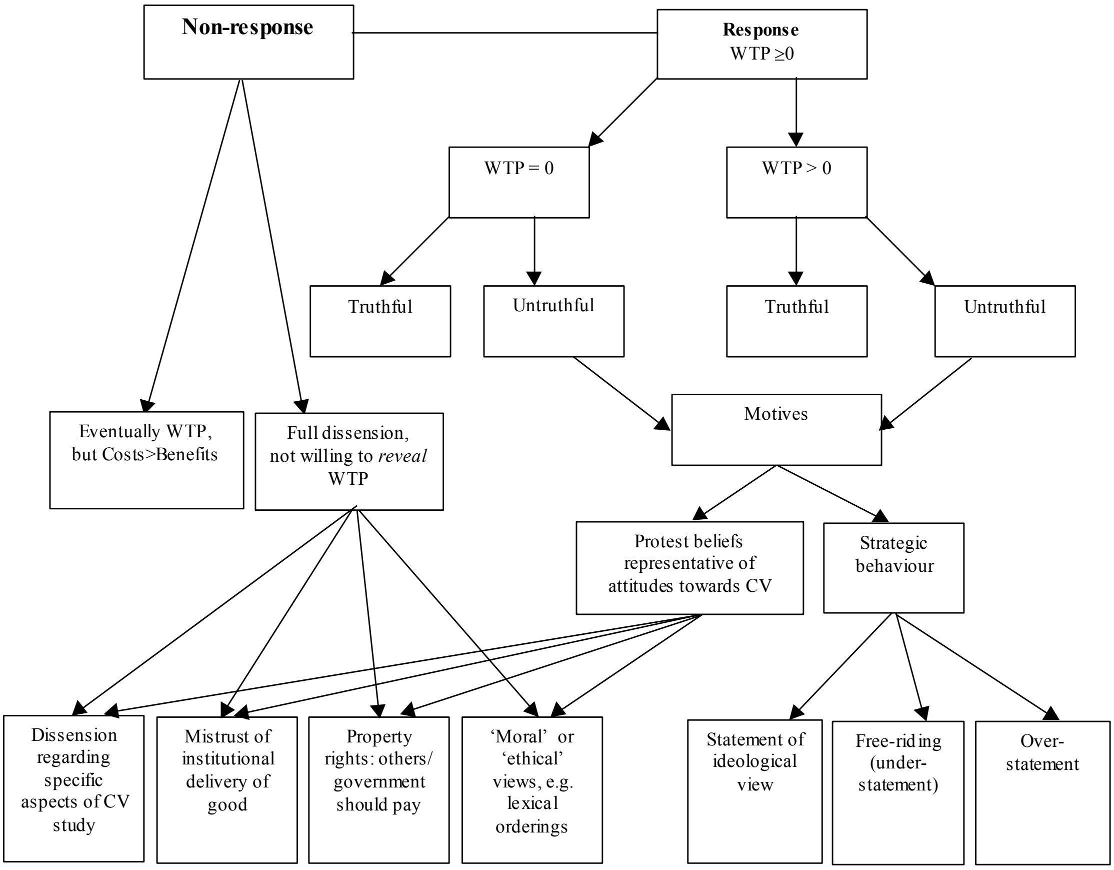
One of the possible reasons for non-authentic zero bids is *protest behaviour*. We can define protest bids as untruthful answers to the valuation question, given because of a desire to express protest. Although we expected some degree of protest behaviour from the anglers fishing in the Ticino River, we decided to apply both the Contingent Valuation and the Hypothetical Travel Cost Method for the estimation of the recreational benefits from a low flow alleviation. However, given the unexpected dimension of protest behaviour from anglers participating in our survey, we felt that the *CV* results would hardly represent true preferences for a low flow alleviation. Therefore, the empirical mean and median *WTP* values reported at the end of the chapter only have illustrative purposes, and do not claim to be valid and reliable. The main interest of this chapter lies in the illustration of the problem of protest bids.

Section 4.1 first presents the possible responses to the valuation question, with focus on zero *WTP*. Section 4.2 reports on some theoretical testing to explain protest bids, while section 4.3. illustrates how protest bids are normally dealt with in practice. Section 4.4 analyzes the *WTP* data collected in our survey to see if there is a problem of protest bidding, preventing the use of the Contingent Valuation Method in the valuation of a hypothetical low flow enhancement in the Ticino River.

4.1 Defining protest bids

Figure 7 shows the possible responses to the valuation question in Contingent Valuation studies. A first distinction to be made is between responses and non-responses. An individual might refuse to give an answer to the Willingness To Pay question or even to the whole survey questionnaire. The amount of bias caused by non-responses is a function of the measure of the bias relative to the initial sample and the extent to which non-respondents would differ in their answers from respondents (Schuman, 1996). It is therefore important to keep the portion of non-respondents as low as possible. In cases where sample non-response occurs because the costs of responding to the questionnaire outweigh the benefits, respondents can be given some material/monetary incentive to answer the questionnaire, such as for example a seasonal angling licence for recreational anglers. If non-response is an expression of full dissension, the matter of getting people to respond becomes more complex and will not be investigated here. For more details on this issue see for example Cameron et al. (1999). When the issue is item-non-responses, referring to the case where only the *WTP* question has remained unanswered, econometric approaches can be applied to re-weight the sample, just as in the case of non-representative samples (Bateman et al., 2002; Dalecki et al., 1993).

Figure 7 - Untruthful bidding[20]



Interviewees who respond to the questionnaire can be divided into those stating a zero *WTP* and those with a positive *WTP*, as displayed in Figure 7. All responses (i.e. zero and non-zero) may be truthful or untruthful. Zero *WTP* bids are truthful if people are genuinely indifferent towards the valued good or service. Untruthful answers might be due to the perceived possibility of strategic behaviour, or due to protest behaviour. While both strategic bids and protest bids have the effect of distorting the Contingent Valuation results, the underlying reasons differ. Strategic behaviour means individuals reporting values which they hope will influence the results of a survey in directions that they view as being favourable to them (Cummings & Harrison, 1992). Protest behaviour is the refusal to reveal true value as a form of protest. Reasons for protesting are manifold. They may be expressions of mistrust in institutions, i.e. a disbelief in the scenario for the delivery of the good, dissension regarding the proposed means of bringing about the change in the public good (e.g. payment vehicle, proposed policy intervention, etc.), an ethical objection to the idea of placing valued environmental objects in a market context, that is lexicality of preferences (Spash & Hanley, 1995; Spash, 2000; Rekola & Pouta, 2001), beliefs that paying for environmental quality is the responsibility of government rather than individual citizens, etc. (see for example Jorgensen & Syme, 2000).

[20] Figure based on a personal communication of David Pearce, Professor at University College London, UK.

To recap, a protest response can be defined as an answer to the valuation question that is *not given truthfully because of some protest reason*. Note that this definition rules out untruthful responses due to strategic behaviour since their underlying motives are different from those of protest bids. Note furthermore that this definition includes the possibility of non-zero bids to represent a protest bid. This suggests it would be expedient to apply follow-up questions to the whole sample and not only to protest bidders in order to test for their legitimacy.

4.2 Theoretical explanations of protest bids…

The Contingent Valuation Method as a technique for eliciting preferences relies on the neo-classical or *hicksian consumer theory*[21] (see for example Mitchell & Carson, 1989). In the neo-classical framework, it is possible to connect preferences with choices – at least for private market goods. Applying this theory to the case of public goods results in some implications that are inconsistent with empirical evidence (Sudgen, 1999a). In fact, the Contingent Valuation Method appears to produce results, which are inconsistent with the assumptions of the neo-classical theory of preferences (Arrow et al., 1993). Protest bids are indeed an empirical anomaly, which is difficult to explain in this theoretical framework.

We can identify three broad reasons why Contingent Valuation Studies produce results which do not conform to the expectations of the underlying neo-classical model of choice (Sugden, 1999b):

1) Random errors and unsystematic inconsistencies;
2) Flawed study design;
3) Defective theoretical model either with regard to fundamental premises or with regard to supplementary assumptions.

If empirical anomalies are due to random errors or unsystematic inconsistencies, there is nothing the researcher can do about it.

Otherwise, empirical anomalies might be the result of biases induced by the elicitation procedure (flawed study design). To the extent that zero bids are signs of strategic behaviour, Sugden (1999a) points out that mechanisms designed to elicit preferences can be made *incentive-compatible*, i.e. whatever a respondent's true preferences, it is in each respondent's interest to give truthful answers[22].

If we exclude the possibility of biases induced by random errors or the elicitation format, protest bids of the Hicksian (neo-classical) model represent real decision-making. The theoretical restrictions of demand theory do not generally hold in practice. Hence, it might be necessary to

[21] The neo-classical theory of demand assumes that (see any microeconomic textbook, such as Varian, 1999):

1) Individuals have underlying preferences which are well-behaved, i.e. adequately comprehensive, stable and coherent. *Comprehensive* means that individuals must be able to make meaningful preference comparisons. *Stable* implies that preferences must not vary arbitrarily over time, and that different theoretically valid methods of eliciting a person's preferences should yield the same results. *Coherent* means that the preferences that are elicited for any person must be internally consistent, as viewed in the light of some acceptable theory of preference (Bateman et al., 2002);
2) individuals' choices reflect those underlying preferences;
3) individuals are able to express their preferences over any and all sets of options;
4) individuals will maximise their wellbeing by buying the set of goods that has the highest utility, given an individual's budget and the prices of the goods.

[22] However, incentive-compatible mechanisms are sometimes quite complicated and a respondent might not understand their incentive-compatible nature.

consider the implications of modifying the assumptions of the standard model or at worst to acknowledge that for some goods respondents may have preferences that do not conform to any formal model, because only partially formed, imprecise or labile.

Some analysts suggest that protest bids are evidence for *lexicographic preferences* (Spash & Hanley, 1995; Spash, 2000). Lexicographic behaviour refers to the situation where individuals may be unwilling to trade-off increases/decreases in the quality of some environmental good against losses/gains in income. This might be because of rights-based beliefs, i.e. the conviction that the existence of certain environmental amenities should not be traded for money. This behaviour is different from what would be expected by the neo-classical theoretical framework.

If only a small minority of people in society have lexicographic preferences, the problem might be negligible. However, if there is a prevalence of preferences that are lexicographic in their nature, the elicited *WTP* values for an environmental quality improvement cannot be used in cost-benefit analysis (*CBA*), since they do not represent an unbiased benefit measure.

If we assume that the abnormalities in the neo-classical view in reality are regularities that exist in the real world, new theoretical approaches have to be developed, which better explain real decision-making. A non-hicksian model of decision-making, the *reference-dependent preference theory*, was developed by Tversky & Kahneman (1991). The fundamental idea of this model is that individuals understand the options in decision problems as gains or losses relative to a reference point. The reference point is normally the current asset position of the individual.

As Sudgen (1999a) notes, "[…] it seems that in order to explain individual behaviour in relation to public goods we have to take account of factors other than preferences. In particular, we have to take account of the expressive value of actions, and of the moral making which can explain how these factors work together, and which can allow a *CV* researcher to disentangle them. As yet, no theory of choice seems sufficiently well-developed to do this reliably. Until these fundamental theoretical problems have been solved, attempts to elicit preferences for public goods must be treated with caution." (Sugden, 1999a, p. 149).

4.3 … and treatment in practice

In the meantime, ways need to be found which can help enhance the credibility of results from Contingent Valuation studies. It is clear that estimates of total *WTP* depend on the treatment of zero bids. However, the unresolved issue at the theoretical level is reflected in the practice of non-market valuation: there does not appear to be any agreement over what constitutes a protest response, let alone over how to identify and treat it. This is highlighted by the literature survey of 18 CV studies reported in Table 4.

The series of studies included in this survey was deliberately confined to water bodies (groundwater, rivers, wetlands, coastal water), since the definition of protest responses and the rules for censoring them may vary according to the type of good being valued (Jorgensen et al., 1999).

Strikingly, we can identify only a small set of studies caring explicitly about zero bids (column 9). In fact, only 8 out of 18 studies seem to have bothered to sort out protests from genuine zeros by following up refusals and zeros and to report this procedure in detail. In the rest of the studies, either no mention at all is made of protests, or no information is given on the number of protest bids and on how they have been identified as protesters. The application of criteria, which screen protest responses from genuine responses, seems to be used in a merely ad-hoc manner. It is a common characteristic of the published literature for comments regarding protest criteria to be either absent or vague.

Since empirical evidence suggests that zero responses and protest bids may represent a huge part of the total sample, the practice of censoring protest bids is very likely to bias the sample, consequently undermining the claim of generalisability of the results on the basis of representative sampling. Moreover, the current practice of applying ad-hoc decision rules implies that estimates from Contingent Valuation surveys may be affected by the procedures to determine the final sample used in the analysis of responses. Two *CV* analyses conducted independently on the same good with comparable population samples may lead to different mean and median *WTP* estimates, depending upon how the practitioner has organised the data. In fact, a major concern in screening a given data set for bids that do not fit with an economic interpretation of value is that the screening may have some systematic bias on the results of the analysis (Bateman et al., 2002). The aggregate *WTP* value in this case will only have significance for the sample from which is drawn and cannot therefore be used for policy decisions.

As this sample of studies would seem to indicate, we can say in conclusion that the lack of information about the screening process is hardly very reassuring for the application of *CV* studies in *CBA*. In fact, most studies report the identification procedure and the treatment of protest bids at best only vaguely. Therefore, first of all, *CV* studies should include explicit information on zero bids and the screening procedure for protest responses.

In order to enhance the validity of Contingent Valuation results, several authors (Desvousges et al., 1987; Lindsey, 1994; Jorgensen et al., 1999; Jorgensen & Syme, 2000) have proposed to establish criteria on the basis of which practitioners should decide when a zero bid represents a protest response. In fact, the validity of aggregate WTP values is questioned when estimates vary according to ad-hoc censorship rules applied by some practitioners and not others. However, as Jorgensen et al. (1999) point out, it is possible, that protest responses and their meaning vary according to the type of good being valued, the elicitation format, and the interaction between these elements and external factors. This premise renders the development of unambiguous rules for censoring protest responses difficult if not impossible. Further theoretical research is needed.

There are also empirical attempts to accommodate for zero bids (Reiser & Shechter, 1999). Kontoleon and Swanson (2001) apply an econometric model known as *Double Hurdle Independent model* (DHI). This approach models the individual's *WTP* bid as a decision in two steps: first the decision to comply with the contingent market (i.e. not to protest) and second a payment decision. Therefore, no protest bids are dropped from the sample but are instead included in the estimation process.

Table 4 – Literature review

	1	2	3	4	5	6	7	8	9	10
	Author(s)	Good valued	Country, Area	Survey Method	Units contacted, Sample size	Elicitation format**	Payment vehicle	"No" responses/ total zero bids (including protest bids)	Protest responses (% of original sample or usable sample?)	Estimation Methodology
1	Berrens, Bohara, Silva, Brookshire, McKee (2000)	Protecting instream flows	USA, Rivers of New Mexico	Telephone survey	1995: 698 (ca. 2100 numbers dialled) 1996: 711 (ca. 2000 numbers dialled)	DC	Voluntary contribution trust fund	1995: 55% 1996: 56%	Not specified	ML -Logistic -Log-logistic -Weibull -Log-normal
2	Blomquist, Whitehead (1998)	Wetland preservation	USA, Western Kentucky coal field	Mail survey introduced by phone contact	730 contacted by phone 641 included in mail survey Sample: 379	DC	Voluntary Contributions to Wetland Preservation Trust Fund	45.6% (protest bids already excluded)	40.9% (262/641) protest bids + non-responses. However, not specified how many protest bids only.	Logit and Cameron technique
3	Daubert, Young (1981)	Maintaining instream flows	USA, Colorado mountain stream: Cache la Poudre River in northern Colorado	Personal interviews	49 anglers 45 shoreline recreationists 40 white-water enthusiasts Sample: 134	IBG	-Entrance fee -Sales tax	Not specified	Not specified in a quantitative way.	Stepwise LS
4	Desvousges, Smith, Fisher (1987)	River water quality improvement	USA, Monongahela river	Personal interviews	393 households, Sample: 301	-OE PC -OE -IBG	Tax or higher product prices	Not specified quantitatively	19% (58/301)	OLS
5	Edwards (1988)	Groundwater protection	USA, Cape Code, Massachussets	Mail survey	1000 Cape Cod households, Sample: 585	DC	Bond vehicle (i.e. public referendum vehicle)	Not specified	4.3% (43) protest to the payment vehicle 9.1% (91) protest because of information lack 3.6 % (36) protest refusing putting a monetary value on groundwater	Logit
6	Garrod, Willis (1996)	Enhancing river flow	UK, River Darent, South East England	Personal interviews	Use values: -325 residents -335 visitors Non-use values: 758 households	OE	Annual water rates	Zero bids not specified	Illegitimate zero bids cancelled form sample, however not specified quantitatively	OLS
7	Gonzales-Caban, Loomis (1997)	Preserving instream flow in Rio Mameyes and avoiding dam on Rio Fajardo	Puerto Rico, Rio Mameyes and Rio Fajardo	Personal interviews	Grand San Juan: 230 San Juan Sub-Region: 100 Ponce: 100 Mayaguez: 100 Arecibo: 70 Total sample size: 600	DC	Water conservation trust fund	68%	36.9%	Double-bounded logit
8	Green, Tunstall (1991)	River water quality improvements	UK, 12 sites at watercourses in England and Wales	Not specified	Sample: 386	IBG	Water rates	IBG " no" responses: 47%	Not specified	OLS
9	Greenley, Walsh, Young (1981)	River water quality preservation	USA, South Platte River Basin	Personal interviews	202 households Sample: 162	IBG	General sales tax Residential water-sewer fee	40% Unwilling to Pay (20% full dissension and 20% zero bids)	Not specified quantitatively, although reasons for the 20% zero bids were given	Not specified

									(protest and genuine 0)	
10	Johnson, Adams (1988)	Increasing streamflow	USA, John Day River, Oregon	Personal interviews	Sample: 62	OE	Fee in form of steelhead stamp	Not specified	Not specified	OLS
11	Jordan, Elnagheeb (1993)	Improvements in drinking water quality	USA, Georgia	Mail survey	567 Georgia residents 192 completed questionnaires Sample: 180	PC	Water bill	11.1% (20/180)	0% No zeroes could be identified as protest responses	ML
12	Le Goffe (1995)	Improvements in Coastal Water Quality -Salubrity -Ecosystem	France, Brest natural harbour, western France	Personal interviews	Sample: 607	PC	-Water rates -Participation to a special fund WB, FU	Salubrity 25% Ecosystem 51%	Salubrity 20% Ecosystem 45%	Tobit
13	Loomis, Kent, Strange, Fausch, Covich (2000)	River water	USA, 45-mile stretch of South Platte river	Personal interviews	462 contacted Sample: 96	DC	Higher water bill	36.8%	Not specified	Logit
14	Milon (1989)	Development of a marine artificial reef	USA, Dade County (Florida)	Mail survey	3600 boat owners Sample: 1182	-Contribution -DC -OE Bidding game	-Voluntary donation to trust fund -tax to trust fund	51.3%	8.5% (101/1182)	Contribution and DC: ML discrete regression procedure due Cameron (1988) OE Bidding game: two-limit tobit model
15	Morrison, Blamey, Bennett (2000)	Preservation of two Australian wetlands: Tilley Swamp, Coorong	Australia, Upper South East region of South Australia	Mail survey	1648 households in New South Wales and South Australia Sample: 778	DC	-Income taxes -Water rates	Not specified	Income taxes: 16% (60/376) Water rates: 14.4% (58/402)	Logit
16	Romina Cavatassi (1999)	Groundwater quality	Italy, Bologna	Personal interviews	100	PC	Water rates	22% (22/100)	11% (11/100)	ML for interval data
17	Shultz, Lindsay (1990)	Groundwater protection	USA, Dover, Nuew Hampshire	Mail survey	600 Dover property owners Sample: 346	DC	Extra property taxes	69%	2.3% (14/600) refusals and/or protests	Logit
18	Stenger, Willinger (1998)	Preserving groundwater quality, Alsatian aquifer	France, Alsatian aquifer	Personal interviews	1'000 interviews Sample: 817	DC followed by OE	Water bill	DC: 30.7% (251) OE : 13.1% (107)	Not specified	DC: Logit OE: OLS Hanemann's linear utility model

*Option Value=Option Price – Consumer Surplus
**DC=DICHOTOMOUS CHOICE, PC=PAYMENT CARD, OE=OPEN-ENDED QUESTION, IBG=ITERATIVE BIDDING GAME

4.4 Protest bids and WTP for a low flow enhancement in the rivers of Ticino

As Jorgensen et al. (2001) point out, decisions on how to treat zero bids affect the estimates of total *WTP*. Hence it is clear that the nature of zero bids has to be scrutinised in order to be sure that no untruthful zero bids are included in the analysis, thereby flawing the *CV's* results.

The Contingent Valuation is a frequently used approach for the valuation of low flow enhancement of rivers (see for example Daubert & Young, 1981; Desvousges et al., 1987; Green & Tunstall, 1991; Garrod & Willis, 1996; Willis & Garrod, 1999). It has also been applied to the valuation of a low flow enhancement in Ticino's rivers[23]. For a presentation of the whole survey, see chapter 5. This section focuses on the analysis of zero bids to the *WTP* question.

The *WTP* question for a low flow enhancement in the rivers of the Canton of Ticino was formulated in the following terms (see Appendix 4 for the whole questionnaire):

> "Anglers have been claiming for a long time that low flows in the rivers of the Canton of Ticino should be alleviated in order to enhance angling conditions. For illustration purposes, the attached photographs show a possible change of the flow levels.
>
> Imagine the following hypothetical situation: the level of low flows in the rivers of the Canton of Ticino is alleviated and fish population therefore increases significantly (by ca. 250 trout per river km).
>
> The low flow alleviation enhances fishing conditions. However, it also causes losses in terms of a reduction in energy production.
>
> Could you please indicate how much you would be willing to contribute annually for an enhancement of low flows?"

WTP bids have been elicited with the help of an open-ended payment card[24]. The final sample consisted of 381 observations[25]. 205 individuals (53.8%) say they have a zero *WTP* for a low flow enhancement in the rivers of the Canton of Ticino (see Appendix 3 for the *WTP*-distribution). Considering anglers' interest in higher flow levels given the negative impact of low flows on fish population, this high share of zero bids might be an indicator of protest behaviour.

The reason for protesting might be found in the question format: asking for Willingness To Pay for a flow level enhancement implies that recreational anglers do not hold property rights for increased flow levels. However, Ticino's recreational anglers feel that it is their right and that they should not have to pay. Additionally, a price-rise of the angling license just before the survey probably led anglers to protest any further payments. Given these circumstances, a careful scrutiny of the *WTP* bids is warranted. More specifically, it is important to screen zero bids for genuine and non-genuine statements of preference.

As stated before, there is no standard procedure for screening zero bids for genuine zeros and protest bids. We included two specific questions in the questionnaire in order to validate anglers'

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[23] The information was gathered in the survey carried out for the valuation by the Hypothetical Travel Cost Model presented in chapter 5, where the collection process and the data are illustrated in detail.
[24] By open-ended payment card we mean a matrix of values ranging from 0 to 190 SFr. with the possibility to state any other or higher amount.
[25] 263 observations of the 644 anglers who answered the mail survey could not be used either because of missing data or inconsistent or implausible answers to the questionnaire. A brief description is found in Appendix 2.

zero *WTP* bids, one eliciting the underlying reason for a zero bid, and one analysing anglers' intended behaviour (contingent behaviour) given a low flow improvement.

The first, mentioned above, was a "classical" follow-up question aiming at eliciting anglers' motives for a zero bid[26]. Confronting the zero bid with the stated reasons for refusing to pay a contribution for a low flow enhancement program is supposed to give some indication of the validity of the response.

The answers to the open follow-up question are reported in Table 5. The single most often cited responses were *"Hydropower plants should pay (Polluter pays principle)"* (17.6% of zero bids) and *"Fishing licence is too expensive"* (13.7% of zero bids) whilst the most infrequent response (a part from those who failed to give a reason at all) was "*Do not believe that the situation will change*" (1% of zero bids).

Table 5- Frequency of protest reasons

Number	Reason	Frequency of answers	% of zero bids
1	Hydropower plants should pay	36	17.6
2	Multiple statements (no 13 or 14)	29	14.1
3	Angling licence is too expensive	28	13.7
4	Perceived unfairness of having to pay extra tax/not only anglers should pay	23	11.2
5	**Not interested in an increase of low flows**	**18**	**8.8**
6	Public good	11	5.4
7	Don't know	10	4.9
8	Other reasons	10	4.9
9	If existing laws were respected, there would be no problem	9	4.4
10	Nobody should have to pay for the nature	7	3.4
11	**I'm not in a position to afford it**	**5**	**2.4**
12	Less energy production through energy saving/alternative energies	5	2.4
13	Use revenues from angling licence	5	2.4
14	State government should pay	3	1.5
15	**Low flow is no problem for me**	**3**	**1.5**
16	Do not believe that situation will change	2	1.0
17	No answer	1	0.5
	ZERO BIDS	**205**	**100**
	GENUINE ZERO BIDS (lower bound)	**26**	**12.7**

Reasons that are frequently assumed to be valid zero bids without controversy are "*Not interested in an increase of low flows/Low flow is no problem for me*" (reasons 5 and 15) and "*Not being in a position to afford it*" (reason 11). However, other views that change the final outcome might be possible. Considering only the most obvious motives for protest, only 26 respondents out of the 205 (12.7%) who stated a WTP of zero seem to have given a true statement of the value they attribute to an increase of low flows. This implies that 47% of all the WTP answers are protest bids.

The second question, introduced in order to estimate the benefits of an environmental quality change using the Hypothetical Travel Cost Model, was also used to check anglers' behavioural response to a low flow enhancement. Anglers were asked how they would modify their actual angling trips given a hypothetical low flow enhancement:

[26] If respondents indicated a *WTP* equal to zero, they were asked in a follow-up question to state the reason, providing three answer options: (1) I am not interested in a low flow enhancement, (2) I don't know, (3) other (to be specified by the angler).

"Given the hypothetical low flow enhancement and therefore the improved angling conditions because of increased fish populations, could you please indicate by how much you would change the number of trips to your three most preferred angling sites?"

Given the answers to this contingent behaviour question, the zero bids were validated, that is zero bids were separated into true zero bids and protest zero bids. We make the supposition that zero bids are only authentic if behaviour does not change with a quality improvement.

Table 6 reports how many of the respondents who stated zero *WTP* give coherent answers when asked about their intended behaviour given a quality improvement. On this basis, 96 out of 205 (46.8%) zero bidders would be judged to have genuinely no interest in a low flow enhancement and that this quality improvement has therefore no value to them.

Table 6 - Analysis of zero bids

WTP (SFr.)	Trips after an increase in low flows (behavioural intention)	Genuine zeros on basis of behavioural intention	Genuine zeros on basis of follow-up question
0	No response	20	3
0	0 trips	76	15
0	>0 trips	0	8
	TOTAL	**96**	**26**

The summary Table 7 highlights the discrepancy between the number of zero bids believed to be genuine from the two validation questions. With the follow-up question, 12.7% of the zero bids seem to be authentic zeros, while the question on the intended behaviour seems to reveal that a much higher share, namely 46.8% of the zero bids, genuinely has no interest in a low flow enhancement.

Table 7 - % of protest zero bids identified with two different authentication protocols

	% protest zeros of total zero bids	% protest zeros of total sample
Stated reason	87.3	47.0
Contingent (intended) behaviour	53.2	28.6

This discrepancy could be explained by assuming that anglers better enjoy their trips without adapting their behaviour to the quality improvement. This means that observations might be counted as genuine zeros when in fact they are not. On the other hand, 8 observations of the individuals stating a valid motivation for their zero bids indicate at the same time an increase in trips following an enhancement of low flows.

This simple analysis suggests that the current practice of presenting respondents with additional questions aiming at identifying genuine zero bids is highly arbitrary. The researcher's conclusions on the authenticity of zero bids in fact depend on the type of follow-up question and on the interpretation of the responses. *CV* results vary accordingly, as can be illustrated with the empirical mean and median *WTP* values for a low flow alleviation in Ticino's rivers reported in Table 8[27]. When no zero bids are excluded from the statistics implying that all zeros are believed to be authentic bids, the median *WTP* is equal to zero, given that more than 50% of

[27] In reality, *WTP* data are in interval form, given that they were collected with a payment card. The true value hence lies somewhere between the value ticked on the payment card and the next-lowest value. Therefore, an analytical model would be needed for correct estimations. However, as a conservative approximation, we calculated mean and median *WTP* on the basis of the lower value.

the sample stated zero *WTP* amounts. The mean *WTP* is 27 SFr., a rather low willingness to contribute annually to a low flow alleviation, given that the mean number of trips is 32 trips per season (see Appendix 2). Excluding from the sample those zero bids which are believed to be protest zeros gives the following picture: based on the follow-up question which asks for the motives for a zero bid, the mean value amounts to 50 SFr., while the median value is 40 SFr. With the question asking for the intended behaviour given a low flow alleviation (contingent behaviour), the values decrease to 37 SFr. and 20 SFr., respectively. This is because in our case, as already stated in Table 7, with contingent behaviour a higher share of zero bids is identified as genuine zeros than with the follow-up question.

Table 8 - Empirical Mean and Median WTP

EMPIRICAL WTP (in SFr.) (Lower bound)	Mean	Median
Including protest bids	26.6	0
Excluding protest bids on basis of "reason"	50.1	40
Excluding protest bids on basis of "contingent behaviour"	37.2	20

The fact that zero bids cannot be identified unambiguously strengthens the concerns about the validity and reliability of benefit estimation with the *CVM*. However, even if it were possible to identify protest bids with a high degree of confidence, simply excluding them from the sample still risks distorting the estimates since it might well be that protesters are characterised by a latent *WTP* which differs from the *WTP* of the rest of the sample. Hence, protest bids should only be excluded from the sample if the characteristics of protest bidders do not differ significantly from those of other respondents whose bids are accepted as legitimate (Jorgensen et al., 1999). In this case, the observed *WTP* pattern can very likely be extended to the non-protesters. If not, the exclusion of certain responses on the grounds of the follow-up question would discriminate against certain segments of the sample since their views or preferences are not accounted for. The direction and the magnitude of the bias thus depend on the latent *WTP* of the protesters. The problem is obviously magnified as the number of zero responses increases and is hence particularly important in our case where the dataset includes a huge amount of zero responses.

These issues shed serious doubts on the validity and reliability of *CVM* results of benefits from a low flow alleviation in Ticino's rivers. In short, the simple descriptive analysis of the *WTP* responses strongly suggests that a substantial share of the zero bids are protest bids. Given that it seems highly improbable that we can unambiguously identify protest bids, and given also that deleting protest zeros might introduce sample selection bias, this approach has not been taken into further consideration for the benefit estimation of a low flow enhancement.

Chapter 5: Valuing a hypothetical low flow enhancement in the Ticino River for recreational anglers

The last few decades have seen major advances in the methodology used for the economic valuation of environmental amenities. One of the latest developments consists of the combination of revealed and stated data for the valuation of an environmental quality change, such as for example the Hypothetical Travel Cost Model (Layman et al., 1996). The approach was briefly introduced in chapter 3, where some of its gains were discussed, in particular the possibility of valuing hypothetical quality improvements in a behavioural framework rather than with the Contingent Valuation Method. This is particularly important when doubts exist on the reliability and validity of *CV* results.

The aim of this chapter is to illustrate the application of the Hypothetical Travel Cost Model (*HTCM*) for the valuation of a low flow alleviation in rivers. The goal is to estimate the additional benefits accruing to recreational anglers from a quality improvement. Although the survey considered all rivers of the Canton of Ticino, results will be presented for the Ticino River and selected sub-regions, given that this river is particularly affected by low flows and around 60% of anglers frequent it.

The chapter is structured as follows: section 5.1 presents the issue of low flows and the area of study. Section 5.2 shortly illustrates the theoretical idea underlying the Hypothetical Travel Cost Model. Section 5.3 presents the model specification used to estimate the recreational benefits accruing to anglers from a low flow alleviation in the Ticino River, while section 5.4. reports the empirical results.

5.1 The issue of low flows, study area and data source

Low flows, as already mentioned in detail in chapter 1, have become an issue in the rivers of the Canton of Ticino with the increasing importance of energy production since the 1940s. The Canton's water abundance, together with important height differences led to the construction of hydropower plants and dams[28]. This development has substantially modified the landscape and the natural environment of the Canton's rivers. In particular, water abstraction adversely affects fluvial ecosystems and the aesthetic attractiveness of the rivers for recreational activities, such as canoeing, boating, hiking, recreational fishing, and others.

Cantonal authorities have to value if from society's point of view the benefits from a hypothetical low flow alleviation program outweigh the costs of measures to implement it. A substantial part of the benefits are expected to accrue to recreational anglers. In fact, recreational anglers have a direct interest in river water flows, since low flow levels and frequent artificial flow alterations considerably reduce fish stocks and hence angling success. Hence, in considering flow enhancement measures, the non-market valuation of recreational angling constitutes an important part for the overall assessment cantonal authorities have to undertake in their decision-making process.

The following analysis focuses on the Ticino River, one of the main rivers in the Canton of Ticino. Being a natural habitat of trout populations, the Ticino River attracted approx. 60% of total angling trips in 1998, the year of the survey. The river's spring lies in the area of St.

[28] A substantial part of Ticino's territory is located in the Alps. The difference in height between the St. Gotthard pass and the lake Maggiore in Bellinzona amounts to more than 1700 meters.

Gotthard and, after having crossed the Canton's northern Sopraceneri region, flows into lake Maggiore.

The particular strain put on the Ticino River from hydropower plants becomes evident if we consider that 32 water abstraction points are located along the Ticino River's 90 km course (see Table 1 in Chapter 1). It is clear that in the proximity of these points, low flows tend to be acute, increasing the naturally observed differences in flow levels.

As discussed above, one of the most important features of the Hypothetical Travel Cost Model is, that it allows the estimation of the benefits from a hypothetical quality improvement in a single site. However, considering the whole Ticino River as a single site in the estimation process implies making the strong hypothesis of homogeneous quality conditions. In reality, the Ticino River is not affected everywhere in equal measure by the diversion and abstraction of water for hydropower generation. In some areas, low flows are not an issue, while in others they constitute an important problem. This circumstance may mean that pooling trip data to all angling sites on the Ticino River in order to estimate a single recreation demand function will prove problematic.

One solution could be to introduce some variables on the quality conditions of the sites in the demand equation. Unfortunately, no adequate information on water flow quantity was available in our case. For this reason we decided to perform the analysis on the whole Ticino River and on two small (in terms of low flows) more homogeneous sub-regions. For the analysis at the sub region level, we focused on the Leventina/Blenio area and the Leventina area. Both areas are heavily affected by low flows. The Leventina area is the smallest in terms of the geographical area it covers and sample size, yet still yields meaningful and statistically significant results. This decision to include this area will be discussed in section 5.4.2 where estimation results are presented.

Hence, the focus of our analysis lies on:

- (A): Ticino River;
- (B): Leventina & Blenio area;
- (C): Leventina area.

For the definition of the areas for analysis, see the angling map in Figure 8. Note that with (A) Ticino River, we mean all the angling zones through which the Ticino River flows, including the Blenio area with the Brenno River as the Ticino River's main inward flow. Thus, in terms of angling zones, (A) comprises L1, L2; B1, B2, BD and BZ, (B) consists of L1, L2, B1, B2, while (C) includes L1 and L2 (see also Appendix 6).

Figure 8 - Angling map

Source: Ufficio Caccia e Pesca, Dipartimento del Territorio del Canton Ticino

Data for the valuation task was obtained in 1998 from a cross-sectional off-site postal survey (see Appendix 4) sent to 2'245 recreational anglers living in the Canton of Ticino[29]. The questionnaire gathered information on individual's Willingness To Pay (*WTP*) for a low flow increase, information on trips and related travel costs, and some socio-economic information, such as age and income. For a detailed description of the data collection, see section 5.3.4.

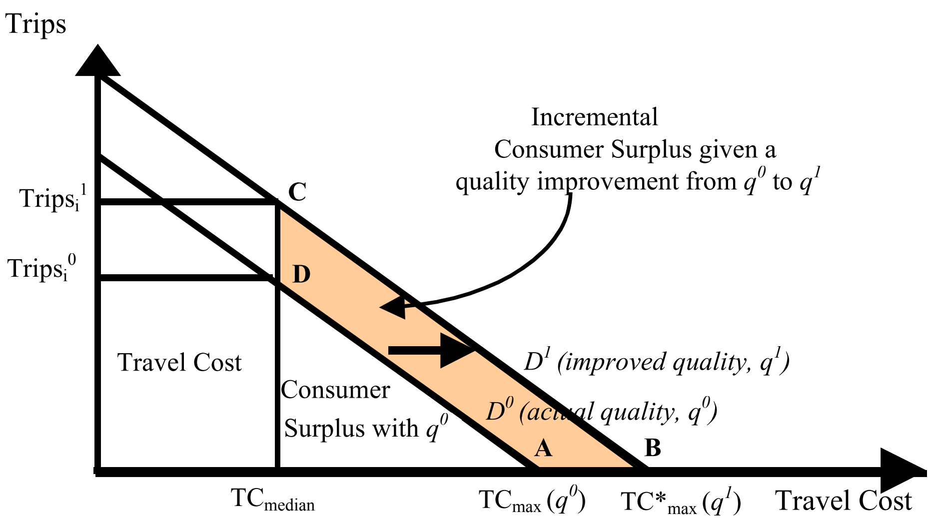
[29] The survey was carried out by MecoP Institute (Istituto di Microeconomia ed Economia Pubblica), Faculty of Economics, University of Lugano, Switzerland, and CEPE (Centre for Energy Policy and Economics), Swiss Federal Institute of Technology, Zurich, Switzerland, commissioned by the Dipartimento del Territorio of Canton Ticino.

5.2 *Estimating recreational benefits of a low flow alleviation: The Hypothetical Travel Cost Model*

A measure of the individual's welfare improvement from a low flow enhancement can be obtained using the concept of marshallian Consumer Surplus introduced in Chapter 2 (section 2.4). Assume a non-marginal increase in river flow levels[30] from q^0 to q^1. If q is an element in the individual's utility function u, this will have an impact on individual welfare. In the behavioural framework of the Travel Cost Model, a rightward shift of the recreational demand is expected from a low flow enhancement if individuals prefer higher flow levels (q^1) over lower flow levels (q^0) (i.e. $q^1 \succ q^0$). q might be interpreted as an exogenously determined characteristic of recreation trips (Freeman, 2003). This is a plausible hypothesis, since river flow increases have a positive impact on fish population, catch rates and hence on the angling experience.

This rightward shift is graphically depicted in Figure 9, where D^0 represents the individual's marshallian demand curve at current quality q^0 and D^1 the new demand given the improved quality q^1.

Figure 9 - Increase in Consumers Surplus from a quality improvement



As stated earlier, the fundamental idea behind the HTCM is to econometrically estimate the shift of the recreational angling demand given a low flow enhancement. The challenge is therefore to correctly characterise the shifted demand (x^*) so that it is possible to estimate the additional use value induced by the higher quality. The problem is that there are no so-called behavioural footprints related to a hypothetical quality improvement. That is, there is no observed data on behaviour given a low flow alleviation on which the shifted quality-improved demand curve can be estimated.

Now, the shift can instead be modelled with the help of stated contingent behaviour data. Contingent behaviour data can be obtained by constructing a hypothetical low flow enhancement scenario. On this basis, interviewees are asked to indicate how they would vary the number of recreational trips given the quality improvement. Given an average travel cost of

[30] Non-marginal changes in environmental amenities are more relevant for economic policy than marginal values, as noted by Herriges & Kling (1999).

TC_{mean} and the current quality q^0, a representative angler is expected to take $T_i^{\,1}$ trips to the angling site, see Figure 9. With a quality improvement from q^0 to q^1, the individual is expected to increase its trips $T_i^{\,2}$ to the same angling site, TC_{mean} held constant. Travel costs can be assumed to be an unbiased measure of the price variable for the hypothetical situation since it does not change with circumstances (Layman et al., 1996). Hence, $T_i^{\,2}$ lies on $x^*(tc, q^1, y)$, the demand function given a quality improvement, and $T_i^{\,2} > T_i^{\,1}$, i.e. the number of trips increases with quality improvements. A detrimental effect analogously implies a leftwards-shift of the demand curve.

Finally, by combining actual and contingent trip information with information on anglers' current trip costs, it is possible to derive the Marshallian Consumer Surplus (*MCS*) as a welfare measure for the quality improvement. The *MCS* is given by the integral of the differences between the marshallian recreation demand function representing the actual situation (x) and the demand function depicting the situation with improved quality (x^*) from the mean/median *TC* to the choke price, i.e. the implicit travel cost which drives demand to zero:

$$MCS = \int_{TCmean}^{TCchoke} \{x(tc, q^1, y) - x^*(tc, q^0, y)\} dtc \qquad (5.1)$$

Graphically, the *MCS* is represented by the shaded area *ABCD* in Figure 9, which is simply the difference between the *CS* when quality is at the new level and the CS with quality at its original level.

A key feature of this approach is that the estimation of the shift is not based on a link between objective or perceived quality and behaviour. This is important given the difficulties revealed preference methods face in meaningfully including quality in the econometric model. Here, the link is explained to respondents who are asked to state their behaviour given the illustrated quality improvement.

However Ward (1987) warns that responses to intended behaviour questions may exhibit some biases associated with hypothetical questions. Loomis (1993) tested the reliability and validity of intended lake-visiting recreational behaviour and found that the intended behaviour appears to be a viable approach to estimate changes in recreation use in response to changes in environmental quality. Thus, when the travel cost method for estimating differences in the rate of visits due to changes in resource quality is not applicable, use of intended trip behaviour appears to be a promising alternative.

Moreover, using actual and contingent behavioural data obtained from a questionnaire where the question on hypothetical trips given the quality change follows questions about actual trips and trip costs increases confidence on the reliability of the stated data. In fact, respondents are reminded of their decisions under actual conditions prior to answering questions about hypothetical behaviour. There is hence no need to define price and payment vehicle, as in traditional *CVM* (Vatn & Bromley, 1994), thus reducing the risk of hypothetical and strategic bias.

In sum, the benefits of combining revealed and stated preference data for the valuation of the welfare effects of a hypothetical environmental quality improvement have been demonstrated in several recent studies (see chapter 3).

The appealing feature of supplementing the Travel Cost Model with stated behavioural data for our case is the identification of preferences for a hypothetical low flow improvement, without relying on a variable that measures low flow levels. This is possible, since the quality change is "translated" into trips contingent on a quality improvement illustrated in a hypothetical scenario. As stated before, quality valuations often fail to meaningfully define and measure quantity. In fact, low flows are measured only in very few points on the Ticino River, providing insufficient variability to produce meaningful estimation results. Using fish catch rates as a proxy of the flow levels involves an endogeneity problem in that the catch rate is also determined by an angler's effort and capability (see for example Morey & Waldman, 1998).

5.3 HTCM model specification

An important part of setting up the non-market valuation task consists in formulating the econometric model. This section discusses the empirical specification of the Hypothetical Travel Cost Model used to estimate the benefits of an improvement in river flow conditions of the Ticino River for recreational anglers. The specification process consists of:

(1) the survey of previous studies;

(2) the choice of regressors and the definition of the travel cost variable;

(3) data collection and elaboration of descriptive sample statistics;

(4) the choice of the econometric model;

(5) the decision regarding the functional form used for curve fitting;

(6) the decision regarding the computation procedure for the consumer surplus.

Note that the issues are interrelated and have to be addressed more or less simultaneously: For example, the estimation procedure to be applied should already be decided on in the data collection process, and the character of possible data sources have important implications for the choice of the estimation procedure.

The appropriate choice of the model specification is not straightforward. The model has to be theoretically plausible, i.e. its statistical characteristics have to reflect the economic theory and its behavioural implications (Bockstael et al., 1990). Moreover, the decisions on specification and estimation issues of the model are dictated by the ease of estimation, and data requirements (Hellerstein, 1992b). Since these decisions all have enormous bearing on the final results, they have to be taken with care.

5.3.1 Survey of previous studies combining *RP* and *SP* behavioural data

Table 9 presents some recent studies that combined revealed and stated preference data for the estimation of the welfare impact of an environmental quality change. The chosen studies all apply the behavioural approach, that is they use the combination of actual behaviour and intended behaviour given a quality improvement (contingent behaviour). The chronological order of presentation enables us to observe some of the methodological developments in analysing the data.

Layman et al. (1996) estimated the economic value of recreational Chinook salmon fishing on the Gulkana River in Alaska under existing and hypothetical fishery management conditions with the Hypothetical Travel Cost Model. The sample was obtained from the Alaskan population of licensed sportfishers and contained information from 343 individuals. The authors pool actual and hypothetical recreational angling trip data in order to estimate the following single-site recreational angling demand function:

$$v_i^j = f(D_i^j, TC_i, TCS_i, Other_i) \quad (5.2)$$

where v_j^i are the trips (actual or hypothetical) to the River by person *i* under the actual and three hypothetical management conditions *j*. The dummy variables D_i^j are demand shifters which control for the three hypothetical cases. TC_i represent the cost for person *i* to travel to the angling site. Furthermore, two substitution sites are included in the model (TCS_i). Other variables specified in the model include socio-economic information such as annual income and education level. In order to take account of non-participants in the sample of recreational anglers, a Tobit estimator was applied. For the actual situation, the per trip CS varies between 19 and 46 SFr. For the hypothetical management conditions, the per trip CS lies between 23 and 72 SFr.

Buchli et al. (2003) apply Layman's (1996) Hypothetical Travel Cost Model to the estimation of recreational angling benefits from a low flow enhancement in the Ticino River. As in Layman et al. revealed actual trip behaviour is combined with stated trip behaviour given the quality improvement in order to estimate a single-site demand function. The trip data were obtained in a mail survey with the regional angler population. The final sample consists of 413 anglers. The main difference from Layman et al. is the estimation of the model by the Heckman sample selection model. The authors conclude that a hypothetical increase in low flows in the Ticino River leads to an increase of annual *CS* of 440 SFr.

Whitehead et al. (2000) estimate with revealed and stated preference data the recreational benefits from a hypothetical policy action to increase fish catches. The authors use a Poisson model on a sample containing 765 observations obtained by a telephone survey with the general population, including participants and non-participants. By using the Poisson Count Data Model, it is possible to account for the positive integer nature of the dependent variable of the model. It implies that the number of trips *x* taken by individual *i* in a particular trip scenario *t* is drawn from a Poisson distribution with mean v_{it}. The mean number of trips v_{it}. depends on the explanatory variables for *x* and individual heterogeneity:

$$v_{it} = f(tc_{it}, stc_{it}, y_i, d_{it}) \quad (5.3)$$

where v_{it} is the number of trips, *tc* stands for the travel cost to reach the site, *stc* stands for the substitute travel costs, *y* is income, *d* is a dummy which accounts for the contingent behaviour data. Given that individuals were asked about their current trip behaviour, their expected recreation trip behaviour with current quality and their expected trip behaviour with a quality improvement, it was possible to construct a panel data set and to analyse it as a random effects Poisson model. The resulting increase in *CS* per season given the quality improvement amounts to 58 SFR.

Hanley et al. (2003) estimate the economic benefits that would derive from improvements in coastal water quality to meet the EU standards for bathing water in south-west Scotland. They combine revealed and stated preference data because the quality change to be analysed lies outside the range currently observed. The data was gathered from an on-site sampling strategy on 7 beaches, obtaining 414 responses. They use a Count Data Model with the mean number of trips specified as follows:

$$v = f(tc, swim, q, s) \quad (5.4)$$

where *v* is the mean number of trips, *tc* stands for the travel costs, *swim* is a dummy for those who would swim after a quality improvement, given they do not swim now, *q* stands for the water quality (measured on a five-point scale), and *s* represents region dummies which account for unobserved site characteristics. The combining of real and hypothetical behaviour allows for the estimation of this model in a panel data format. This makes it possible to eliminate unobserved individual effects on the number of trips. The individual user welfare improvement amounts to 13 SFr. annually.

In sum, the studies cited illustrate the usefulness of combining *RP* and *SP* data to value quality changes at a single site without having to assume that individuals respond to objective measures of site quality. However, they do not address the issue of the heterogeneity of the site under analysis.

Table 9 -Benefit estimation of quality improvements in water bodies: Combined revealed and contingent behaviour approaches

Study	Goal of study	Estimator	Functional form	Results[31]
Layman, Boyce & Criddle (1996)	Estimating recreational fishing benefits on the Gulkana River (Alaska) under hypothetical fishery management conditions	OLS (participants) Tobit (whole sample)	Semi-log	Per trip Consumer Surplus* (SFR) Tobit Actual situation 19-46 Doubling annual harvest 25-61 Doubling daily bag limit 23-58 Season bag limit of five fish 30-72 *Results vary according to assumptions on opportunity costs of time
Buchli, Filippini, Banfi (2003)	Estimating recreation benefits of a low flow enhancement in the Ticino River	Heckman sample selection model	Semi-log	Seasonal CS (SFR) Actual situation: 925 Hypothetical situation: 1364 Improvement: 440
Whitehead, Haab, Huang (2000)	Estimation of recreation benefits of a fixed quality improvement; Albermarle and Pamlico Sound, North Carolina	Random effects panel Poisson	Semi-log	CS per trip (SFR): Current quality: 108; Improved quality: 143 CS per season (SFR): Current quality: 204; Improved quality: 262 CS per season for the quality improvement: 58 SFR
Hanley, Bell, Alvarez-Farizo (2003)	Valuation of coastal water quality improvement in Scotland	Random effects Poisson (negative binomial) panel model	Semi-log	Increase in annual CS for users (SFR): 13

[31] For the currency transformation, the annual exchange rates published in the Statistisches Monatsheft of the Swiss National Bank have been used.

5.3.2 Model specification

An important stage in the model specification is choosing the proper set of explanatory variables to include in the model as well as formulating the hypothesis concerning the direction of their impact on the dependent variable. As pointed out by Ziemer et al. (1980), it is important that the selection of the regressors is consistent with both economic theory and previous recreation demand studies. Standard neoclassical demand theory suggests that demand for a commodity depends on its price, prices of substitute goods, household income, and other variables which are supposed to be related in a systematic way to changes in preferences, such as socio-economic variables. Considering average travel costs a suitable proxy for the price of a recreational visit, the Travel Cost Model can be specified within a neoclassical framework in order to estimate recreational demand.

Equations (5.2) and (5.3) indicate the variables included in the estimation of the Heckman model for the analysis of the welfare increase from a low flow alleviation in the Ticino River. Several variables are assumed to determine both the choice of fishing on the Ticino River (*ChoiceT*) rather than on any other river in the Canton of Ticino, represented by (5.2) and, given this choice, the decision on the number of trips per season (*Trips*) (5.3). The (positive/negative) sign on the top of the variable indicates a priori beliefs regarding the (positive/negative) direction of the impact of the explanatory variable on the dependent variable. The hypothesised relationships will be tested by the econometric estimation of the model.

All the variables used in this specification have been constructed based on the information collected through the survey. See Table 10 for variable description.

$$\begin{aligned} ChoiceT_i = f(&TC_{iT}, TCalt_{il}, DHS_i, DY1_i, DY2_i, DY3_i, DY4_i, DPens_i, DPeriod_i, \\ &DGroup_i, Dpond_i, DSC_i, DLoc_i, Dcar_i, Dhol_i, DHH_i) \end{aligned} \tag{5.5}$$

$$\begin{aligned} Trips_{iT}{}^{k} = f(&\overset{-}{TC}_{iT}, \overset{+}{PLake}_{il}, \overset{+}{DHS}_i, \overset{?}{DY1}_i, \overset{?}{DY2}_i, \overset{?}{DY3}_i, \overset{?}{DY4}_i, \overset{+/-}{DPens}_i, \overset{-}{DPeriod}_i, \\ &\overset{-}{DGroup}_i) \end{aligned} \tag{5.6}$$

This model specification assumes that both the choice of an angler to take at least one trip to the Ticino River (*ChoiceT*) and the frequency decision (*Trips*) depend fundamentally on average costs per trip to reach a specific angling site on the Ticino River *T* (*TC*). Since, as has long been recognised, it is crucial to take account of substitute sites in order to avoid omitted variable bias (Wilman & Pauls, 1987)[32], a variable representing the average cost per trip to an angling site on the nearest lake in Ticino (*TCalt*) has been introduced in both equations. Note that the *TC* parameter is supposed to be negative in both the choice and the frequency decision, implying that an increase in the travel cost leads to a decrease in the probability of choosing the Ticino

[32] "If substitute prices are omitted from the demand function and they are positively (negatively) correlated with own price, then the "welfare triangle" will tend to be an under- (over-)estimate of the welfare measure we seek. But correlation among prices is inherent in cross-sectional observations on recreational activity. Individuals in a sample who live far from a coastal recreational resource, for example, will live far from all shore sites, leading to positive correlation. In other applications where sites and people are distributed more evenly, people who live far from the site concerned may live close to a substitute site and vice versa, causing negative correlation. Multicollinearity problems seem the rule rather than the exception in recreational demand modelling" (Braden & Kolstad, 1991).

River as the preferred angling site and a decrease in the number of trips to the Ticino River. As regards the travel cost to the substitute site, the relationship is hypothesised to be positive.

The variable characterising the Hypothetical Travel Cost Model is the dummy variable *DHS*. This variable distinguishes between the number of angling trips given the actual conditions of the Ticino River and the number of trips given a hypothetical enhancement in terms of low flows. Or, in other words, between revealed and stated trips. This demand shifter allows us to test for the positive effect of the hypothetical low flow alleviation on the number of trips and to measure welfare deriving from a quality improvement.

Other dummies introduced into the model include income, one of the basic variables usually used in explaining individual economic behaviour. However, in activities such as recreational angling, income is likely not to be a relevant factor affecting frequency of visits. To test this hypothesis dummy variables (*DY1, DY2, DY3, DY4*) have been introduced representing four income categories.

The dummy variable *Dpens* tests for whether or not pensioners have a greater propensity to participate to the angling activity on the Ticino River than people who are not retired. In assessing the frequency decision, it is assumed that the number of trips will be different for the two groups, however the direction is not clear a priori. On the one hand, they have a lot of free time, while on the other, the willingness to move may be influenced by subjective health constraints and weather.

The dummy variable *Dperiod* defines two groups of anglers: individuals who fish only during week-ends and anglers fishing more or less during the whole week. On the basis of this dummy it is possible to test the hypothesis that anglers who fish only during week-ends will take fewer trips over the season.

DGroup is a dummy variable that distinguishes between anglers who travel in groups and anglers who travel individually. There is no a priori belief on the direction of the impact of the dummy variable on the number of trips, although it might be hypothesised that travelling in a group will restrict individual freedom, leading to a lower number of fishing trips.

The following dummy variables are included only in the specification of the decision model, since it is assumed that they will have an impact on the decision whether or not to angle on the Ticino River, but not on the frequency of visits: *DPond* refers to individuals who use sportfishing ponds, *DSC, DLOC* and *DTI* are dummies to distinguish anglers' proveniences (Sottoceneri area, Locarno area and Ticino area respectively). *Dcar* indicates angling households that possess more than one car, *DHol* stands for fishing holidays abroad, *DHH* has a value of 1 for households consisting of more than two people. Their sign is not clear a priori.

Table 10 - Description of variables used in the angling demand specification

Continuous variables	
ChoiceT	Indicator variable assuming the value 1 for individuals taking at least one angling trip to the Ticino River during a given angling season and 0 for all others
NV_{iT}^{k}	Number of visits to the angling site on the Ticino River T taken by individual i during an angling season under scenario k, where k=1 corresponds to the actual situation and k=2 represents the hypothetical situation (i.e. a low flow enhancement)
TC_{iT}	Implicit price or round-trip travel cost from individual's i domicile to the angling site j on the Ticino River[33]
$Tcalt_{il}$	Round-trip travel costs faced by individual i for trips to substitute lake angling sites l

Dummy variables	
DHS_i^k	=1 for number of trips related to the hypothetical situation (k=2) and 0 for trips related to the actual situation (k=1)
$DY1_i$	=1 for anglers belonging to the income class 0-25'000 SFr.
$DY2_i$	=1 for anglers belonging to the income class 25'000- 75'000 SFr.
$DY3_i$	=1 for anglers belonging to the income class 75'000-125'000 SFr.
$DY4_i$	=1 for anglers belonging to the income class >125'000 SFr.[34]
$Dpens_i$	=1 for pensioners
$Dperiod_i$	=1 for anglers who take angling trips only during week-ends, 0 when angling both during week-ends and weekdays
$Dgroup_i$	=1 for anglers who travel by car in groups
$Dpond_i$	=1 for anglers visiting sportfishing ponds
DSC_i	=1 for anglers living in the Sottoceneri region
$DLOC_i$	=1 for anglers living in the Locarno area (comprising Maggia valley, Verzasca valley, Onsernone valley)
DTI_i	= 1 for anglers living in the Ticino area (Leventina and Riviera, including the Blenio valley)[35]
$Dcar_i$	=1 for anglers whose households are in possession of more than one car
$DHol_i$	=1 for anglers who regularly spend fishing holidays abroad
DHH_i	=1 for anglers whose households consist of more than two people

5.3.3 Construction of the Travel Cost variable

The crucial variable of the Travel Cost Model is the variable that measures the average costs an angler has to sustain for a typical angling trip. These costs have two main components: out-of-

[33] If an individual takes trips to more than one site on the Ticino River (individual anglers were asked to indicate their trips to the three most preferred sites), the *TC* variable was computed as the weighted mean of the travel costs sustained to reach the different angling sites.
[34] In the empirical analysis, four income classes have been defined. Since every income class is a linear combination of the other three, in the estimation process only three income classes have to be included in the model. In our case, we chose *DY4* as the reference case.
[35] This was the reference case. Hence the dummy for anglers living in the Leventina, Riviera or Blenio valley area was not included in the model.

pocket costs including all variable trip costs such as for example the cost of gasoline for a car, and opportunity costs of travel time.

For the construction of the travel cost variable, TC_{ij}, we follow Layman et al. (1996) and we define this variable as:

$$TC_{ij} = \underbrace{\frac{(\text{Distance}_{ij})(\text{Cost per kilometre})}{\text{Group size}_i}}_{1} + \underbrace{(\%\text{Wage})(\frac{\text{Income}_i}{2000})(\text{Time}_{ij})}_{2} + \underbrace{\text{Fishingbait}}_{3} \quad (5.7)$$

where

Distance$_{ij}$:	Individual angler's *i* round-trip distance from his/her home to the angling site *j*;
Cost/km:	Average kilometre cost for the chosen transport means (mainly car);
Group size$_i$:	Number of persons who travel together on a given angling trip;[36]
%Wage:	Percentage of hourly wage utilised to calculate the opportunity cost;
Income$_i$:	Annual before-tax income;
Time$_{ij}$:	Individual angler's *i* round-trip travel time from their homes to the angling site *j*.
Fishing bait:	Expenditure per trip for fishing bait.

The first term of equation (5.7) represents the *out-of pocket costs*. They have been compiled for the following transportation options: car, motorbike and scooter. Anglers who use bikes or walk by foot incur only opportunity costs of time. Out-of-pocket costs are defined as the number of kilometres per-trip multiplied by the kilometre costs of the chosen transport means divided by the group size. Travel distances and times were obtained using the software Finaplus[37]. The kilometre costs of a car, for example, were assumed to be 33 Swiss cents, representing the variable cost estimate of the Touring Club Suisse for a 25'000 SFr. car travelling 10'000 kilometres per year[38].

The second term of (5.7) represents the *opportunity costs of time,* an estimate of the cost of an individual's time in terms of lost income while he or she is travelling to a fishing site. In order to calculate the per trip opportunity cost of time, ¼ of angler's declared annual before-tax household income is divided by the number of annual working hours in order to obtain an indicative value of the hourly wage rate, which is then multiplied by the round-trip travel time.[39]

[36] In our specific case, the group size in the computation of the travel cost variable (TC_{ij}) is always set to one. This is a simplification dictated by data availability which however should not lead to severe overestimations of the travel cost. In fact, fuel costs, the part of the per km costs that would generally be divided among the group, are only about 15% of total km costs (see Touring Club Suisse, TCS). Moreover, anglers commonly compensate the car holder for the trip ride by a dinner invitation or other little gifts rather than by contributing to the real expenditures.

[37] The software *Finaplus* allows us to obtain precise information on distance and average travel time for every single angler by indicating starting and arrival point.

[38] This assumption lies on the hypothesis that individuals perceive the variable costs as relevant to their trip decision, given that the fixed costs occur anyway. Variable costs are dependent on the number of kilometres driven yearly, and include expenditures on fuel, tyres, repairs etc. Fixed costs include for example insurance and maintenance costs.

[39] Note that due to the fact that we do not have precise information on income (only income classes), we took the average value of each class.

The matter of including *opportunity costs of travel time* in the travel cost has always been considered an important factor in the literature on the *TCM* (see for example Bockstael et al., 1989). The implications of adopting different conventions for measuring time costs for the purpose of estimating consumer's surplus have been analysed empirically for some time now (Cesario, 1976; Wilman & Pauls, 1987). Nonetheless, economists have not reached a consensus yet on the measurement and integration of the opportunity costs of time in recreational demand analyses. In fact, the role of time raises some thorny issues for both the standard travel cost and *RUM* approaches of analysis (Freeman, 2003).

Most applied studies base their estimates of the opportunity cost of time on individual's wage rates, implying that individuals can make marginal substitutions between time and income. Taking a fraction of wage rate is common practice, usually justified by the fact that when people are travelling they might enjoy seeing the sites along the way, they might not be able to work at their current job on the weekends due to institutional constraints, or that before-tax may overestimate the opportunity costs of leisure time (Haab & McConnell, 2002).

Cesario's (1976) 1/3 wage rate-proposal to value recreational travel time has been applied in a number of studies (e.g. Hellerstein & Mendelsohn, 1993; Englin & Cameron, 1996). This practice was supported in a study by Englin & Shonkwiler (1995). Smith et al. (1983b) compare Cesario's (1976) proposal of 1/3 wage rate to travel time valued at full wage rate, concluding that on the basis of their results, they cannot advocate one over the other. They highlight the need for further research in this field since the appropriate valuation of time devoted to recreation trips depends on the nature of the time constraints individuals face (different individuals will have different degrees of flexibility in the use of their free time). McConnell & Strand (1981) suggest letting the sample data determine the proportion of the individual's market wage rate or income per hour. Many studies present results for different fractions of wage rates (see for example Layman et al., 1996), or upper (travel cost including opportunity costs valued at the full wage rate) and lower bounds (only monetary travel costs) of estimated *CS* (Vaughan & Russell, 1982). However, the uncertainty of these estimates should be acknowledged. We decided to value time at ¼ wage rate as a conservative estimate compared to Cesario's (1976).

Equation (5.7) contains a third term including the variable per trip expenditures, such as fishing bait which has been assumed to amount to 6 SFr. per trip, based on information from anglers and angling equipment shops.

Equation (5.7) has been used to calculate travel cost to the angling site on the Ticino River (*TC*) as well as for the travel cost variable for a substitute angling site (*TCalt*) on the nearest lake. In fact, as mentioned above, there is agreement over the fact that the presence of substitute sites constitutes an important factor influencing the demand for recreational trips to a given site. Its omission from the trip generation equation would lead to omitted variable bias to the extent that variables included are correlated with the omitted variables. Consequently, coefficient estimates will be biased and so will *CS* results. The direction and impact of the omission bias depends upon the sign and degree of correlation between the omitted variables and the included variables (Caulkins et al., 1985). Assume there is only one substitute site, and the price variable for that substitute site is positively correlated with the price variable for the given site. In this case, the omission of the substitute price variable will cause the coefficient of the price variable for the given site to be biased upward. That is, the negative coefficient of the price variable will be too small in absolute value, leading to a too large consumer surplus estimate. It has therefore become common practice to collect data on substitute sites to include in the estimation.

5.3.4 Data

This section describes the data collection process and provides a brief profile of the final sample of anglers considered in the econometric analysis. Moreover, some descriptive statistics of the key variables used in estimating recreational demand are discussed. As stated in chapter 1, the focus on recreational anglers for the analysis is motivated by the recognition that recreational benefits constitute an important category of benefits derived from improving river water quality.

The data on recreational angling patterns in the Canton of Ticino needed for the analysis were obtained in 1998 from a cross-sectional off-site postal survey carried out by MecoP and CEPE[40]. A pre-test of the questionnaire with 245 anglers aimed at verifying the comprehensibility of the survey, and at identifying ambiguous and low response rate questions.

The final questionnaire was divided into three parts and can be found in Appendix 4 (in Italian). The first part of the questionnaire considered individual angling habits, such as how often and where they take angling trips, or if they are members of some environmental association. The second part aimed at soliciting the information necessary for the valuation of a low flow level enhancement. For the valuation task, two approaches were adopted. One approach was to pose an open-ended Willingness To Pay-question for a hypothetical quality improvement. Given, however, that there was the fear of protest bidding (see the analysis in chapter 4 confirming this suspicion), a supplementary question was introduced. This question asked for the intended behaviour of the anglers assuming a hypothetical increase in the low flow levels (contingent behaviour). Finally, the third part of the questionnaire regarded socio-economic information such as income, age and gender needed for the demand estimation.

The final questionnaire (see Appendix 4) was sent to 2'000 recreational anglers. Since recreational angling is subject to the payment of a licence fee to the cantonal authority, it was possible to use the existing address register of people having bought an angling licence in 1998 to recruit the sample.[41] In order to incite survey responses, anglers who returned a filled in questionnaire had the possibility to participate to a lottery, raffling 10 annual angling licences worth 200 SFr. each for the successive angling season. The final response rate to the questionnaire was of approx. 30% (644 out of 2'245).[42]

231 of the 644 filled in and returned questionnaires had to be discarded for reasons such as implausibility or inconsistency of the answers or because of missing information. The final sample hence contains observations from 413 recreational anglers, with data on:

(1) the number of angling trips during the 1998 angling season to the respondent's three preferred angling sites on the rivers of the Canton of Ticino;

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[40] Istituto di Microeconomia ed Economia Pubblica (MecoP), Faculty of Economics, University of Lugano, Switzerland, and Centre for Energy Policy and Economics (CEPE), Swiss Federal Institute of Technology, Zurich, Switzerland.

[41] The cantonal address register was used to contact the first 2'000 anglers in alphabetical order. Since a person's name is not supposed to be related in a deterministic way to specific angling habits or individual characteristics, this procedure is supposed to lead to a representative sample.

[42] Given the particular interest of recreational anglers in the low flow issue, this might seem a particularly low response rate, considering also the presence of the monetary incentive of an angling licence. Non-response to a survey may represent a form of protest. Therefore, this low response rate might be interpreted as an indicator of protest behaviour.

(2) hypothetical future trips at the preferred angling sites given a low flow alleviation;

(3) Willingness To Pay data for a hypothetical improvement of low flows, followed by a debriefing question;

(4) additional information needed for the construction of the travel cost variable, such as individual's location of residence, means of transport, etc.;

(5) information on angler's habits;

(6) socio-economic variables.

The observations on the number of actual (1) and hypothetical (2) angling trips were elicited with two questions. The first question simply asked the respondents to indicate the number of angling trips in 1998 to the angler's three most visited angling sites.

The second was worded as follows:

> "Anglers have been claiming for a long time that low flows in the rivers of the Canton of Ticino should be alleviated in order to improve angling conditions.
>
> Imagine the following hypothetical situation: the level of low flows in the rivers of the Canton of Ticino is alleviated and fish population therefore increases significantly.
>
> *(The possible implications of a low flow enhancement on aesthetic aspects have been illustrated with the help of two photographs representing two different flow levels at a representative angling point (see Appendix 1. Moreover, the expected effects on the fish population have been quantified).*
>
> Given the hypothetical low flow enhancement and therefore the improved angling conditions in terms of fish population, could you please indicate by how much you would change the number of trips you take to your three most preferred angling sites?"

Before presenting some statistics on the variables used in the econometric estimation, some general descriptive statistics of the whole sample are presented on sex, age, household income, anglers' geographical distribution, trip distribution to the main rivers, transport means, and angler's satisfaction regarding low flows.

The sample consists of 98% male anglers, having a median age of 41. The distribution of the anglers' age over the sample is relatively even, as shown in Table 11. Hence, recreational angling seems not to be confined to a particular age group but to the male population.

Table 11 - Age distribution

Age category	% Sample
<=20	8.2
21-30	16.5
31-40	22.0
41-50	21.1
51-60	16.5
>60	15.7

Table 12 reveals that a typical angler's household income ranges from 51'000 to 75'000 SFr. Note however, that income has been shown in many previous empirical studies not to be a significant factor in determining recreational angling activity. In fact, it seems that often income levels are more likely to distinguish participants from non-participants than to affect the frequency of the recreational activity (Braden & Kolstad, 1991).

Table 12 - Before-tax (household) income distribution

Income category	% Sample
<=25'000	6.3
25'000-50'000	23.2
50'000-75'000	35.8
75'000-100'000	18.2
100'000-125'000	8.5
>125'000	8.0

As regards the sample distribution of anglers in the cantonal territory, the rivers visited, and the transport means used to reach the angling sites, the descriptive analysis gives the following picture: 46.3% of anglers are from the Sottoceneri region while 53.7% are from the Sopraceneri region (see Table 13). The Lugano area is the most important area of origin, being represented by 32.7% of Ticino's anglers, followed by the Locarno area and the Maggia Valley (23%). The Three Valleys area has the lowest density of anglers (12.6%).

Table 13 - Anglers' origins[43]

Origin		% Sample
Sopraceneri		
	Three Valleys	12.6
	Bellinzona area	19.1
	Locarno & Maggia Valley	23.0
Sottoceneri		
	Lugano area	32.7
	Mendrisio area	13.6

The rivers which attracted most angling trips were the Ticino River (6'488 trips), the Maggia and the Verzasca River (3'403), and the Brenno River (Blenio Valley) (1'169), all situated in the Sopraceneri region. They represent 84% of total trips taken by our sample during the 1998 angling season. This distribution reflects the greater presence of appealing angling sites in the Sopraceneri region.

The most often used means of transport for reaching the angling site is the car (for 85% of the trips) followed by walking (10.2%), while bicycles or scooters are used only marginally. See Table 14.

Table 14 - Transport means

Transport means	% of trips
Car	84.5
On foot	10.2
Bicycle	2.3
Scooter	2.6
Motorbike	0.4

Finally, the vast majority of recreational anglers (88%) claim either not to be very satisfied or completely unsatisfied with the current situation. This refers however to the situation in general in the Canton of Ticino and not to single angling sites.

[43] see Appendix 5 for a geographical map of the Canton Ticino, structured in angling zones specified in Appendix 6.

Table 15 and Table 16 present some descriptive statistics on the most important variables used in the demand estimation. All variables have been computed on the basis of the data collected through the mail survey. These statistics focus on those anglers who take fishing trips to the Ticino River and its tributaries, that is, 297 out of the total sample of 413 anglers. Note that the 116 anglers who have indicated not to take any trips to the Ticino River visit other rivers or go angling on lakes or alpine lakes. The presence of zeros is an important feature of the sample, which will have to be considered in the econometric analysis of the data.

Table 15 shows some descriptive statistics of the continuous variables included in the regression analysis. These statistics are stratified for anglers of group A and group B. Group A includes anglers who only fish during week-ends while group B comprises anglers who take angling trips throughout the week.

Individual information on the number of trips and travel costs are fundamental to the Travel Cost Model. In the survey, each respondent was asked to state the actual number of trips to their three most frequently visited sites and the number of trips they would have undertaken had there been a hypothetical low flow alleviation. Thus, for each angler we have two observations on the independent variable NV_{iT}^{k}. Information on the actual and hypothetical flow situation in the Ticino River was presented to the respondents using two pictures illustrating the effects of an increase in the low flow on the appearance of a representative fishing point on the Ticino River and stating verbally the impact on the fish population. To obtain a count of the total number of trips to the Ticino River in one season, individual trips to all sites on the Ticino River were summed.

Table 15 - Descriptive statistics of the continuous variables used in the regression analysis of the TICINO River (statistics of participants, 297)

Variable	Description	Mean	Standard Deviation	1. quartile	Median	3. quartile
NV_{iT}^{1}	Actual number of trips during the fishing season 1998 to angling sites on the Ticino River					
	Whole sample	26	25	7	16	40
	Group B	28	27	8	20	42
	Group A	17	15	5	10	22
NV_{iT}^{2}	Hypothetical number of trips to angling sites on the Ticino River during a fishing season with an enhancement of low flows					
	Whole sample	36	34	12	24	50
	Group B	39	36	14	27	50
	Group A	25	22	8	17	40
TC_i	Travel cost (SFr.) to reach the angling sites on the Ticino River (opportunity costs evaluated at 25% of the hourly wage rate)					
	Whole sample	41	27	14	41	63
	Group B	39	27	13	39	61
	Group A	50	26	23	53	70
$TCalt_i$	Travel cost (substitute price) to reach alternative recreational angling sites: Lake of Lugano or Lake Maggiore					
	Whole sample	19	15	9	14	23
	Group B	20	15	9	14	23
	Group A	15	10	8	14	19

The descriptive statistics in Table 15 reveal that anglers of group A took on average 17 angling trips to the Ticino River during the angling season 1998, while anglers belonging to group B took 28 angling trips. Under a hypothetical low flow enhancement likely to improve fishing conditions, the number of trips increases on average by 8 units for group A and 11 units for group B, indicating that a low flow alleviation has a beneficial effect on the angling experience. Note, that these values underline the importance of the Ticino River and his tributaries for recreational angling in the Canton of Ticino.

Moreover, the statistics in Table 15 reveal that a typical fishing trip tends to cost more for an angler belonging to group A (50 SFr.) than group B (39 SFr.). This might suggest that week-end anglers who take fewer trips tend to reach more distant sites than those who go more regularly.

From Table 16 containing some sample statistics of the qualitative variables, it can be seen that the majority of anglers who fish on the Ticino River belong to the second income class and take angling trips throughout the week, not only during week-ends. “Only” 18% of the individuals in the sample are pensioners. Interestingly, there is a substantial percentage of anglers who stated that they normally travel in groups, even though this might represent a constraint on the single individual.

Table 16 - Descriptive statistics of the qualitative variables used in the empirical analysis (statistics based on 297 participants)

Variable	Description	% of observations
DHS	=1 if low flow improvement	50.0
DY1	=1 if the annual income lies within the range of 0-25,000 SFr.	5.7
DY2	=1 if the annual income lies within the range of 25,000-75,000 SFr.	58.9
DY3	=1 if the annual income lies within the range of 75,000-125,000 SFr.	27.3
DY4	=1 if the annual income is higher than 125,000 SFr.	8.1
Dperiod	=1 if fishing only during weekends	19.2
Dpens	=1 if pensioner	17.8
Dgroup	=1 if travelling in group (of two or more anglers)	56.9

5.3.5 Econometric model

The choice of the econometric model depends crucially on the nature and structure of the available data. While recreational angling trips are typically non-negative integers, it is the sample design for collecting data which determines if the sampled data contains both data on participants and non-participants (i.e. people who do not angle at a given site or not at all) or only on participants. This has to be taken into account in the estimation procedure in order to avoid substantial bias in estimated coefficients (Hellerstein, 1992b).

Sampling

In studies on recreational behaviour, an important issue concerns participants and non-participants. This is basically a matter of sampling methodology. When data are collected "*on-site*", the sample is said to be "*truncated*" since it only contains information on those who participate in the recreational activity.

That is, observations for the regression equation

$$trips_i = \beta TC_i + \varepsilon_i \qquad (5.8)$$

are available only if $trips_i > c$, where c is a constant and equal to 0 in our case. *Trips* stands for the number of recreational angling trips individual i takes to a site during a season, TC stands for the per-trip travel costs, β is its coefficient to be estimated, and ε is the error term.

Off-site surveys on the other hand include the whole relevant population, and hence include also important information on individuals who do not visit the recreational site under analysis (non-participants). Samples from off-site surveys are typically said to be "*censored*" with the following data structure (see for example Maddala, 1983):

$$trips_i = trips_i^* \quad \text{if} \quad trips_i^* > c \qquad (5.9a)$$

$$trips_i = 0 \quad \text{if} \quad trips_i^* \leq c \qquad (5.9b)$$

i.e. only those values of *trips** are recorded which are greater than c = 0. For the values of $trips_i \leq 0$, the value 0 is recorded.

Both off-site and on-site survey sampling methods have specific implications, which have to be considered in the model estimation procedure. There is a consistent body of literature applying (among other) the Ordinary Least Squares (OLS) estimation procedure to the estimation of recreation demand functions (see for example Layman et al., 1996; Bockstael et al., 1990; Smith, 1988; Kealy & Bishop, 1986). However, OLS applied on *truncated samples* obtained from *on-site surveys* leads to biased coefficient estimates (Maddala, 1983; Smith & Desvousges, 1985). In fact, the application of the OLS estimator requires that the dependent variable takes on values over the full real line. When its value range is restricted in some important way (i.e. the dependent variable is limited), the assumption of the classical OLS model of a zero-meaned error term, $E(u_i) = 0$, is violated.

Similarly, applying an OLS estimator with a *censored sample* leads to biased estimation results since the limit observations (zeros) are included as if they were ordinary observations. Excluding zeros from the sample, that is, simply estimating a demand function on data gathered from users, illustrates the problem of OLS applied on truncated samples OLS mentioned above.

Table 17 - Studies accounting for censoring and truncation

Study	Goal	Estimator
Kealy & Bishop (1986)	Welfare estimation of recreational fishing in Lake Michigan	Truncated Maximum Likelihood (ML)
Smith (1988)	Water-based recreation demand	OLS; Tobit, Heckman, ML, Poisson
Bockstael, Strand, McConnell, Arsanjani (1990)	Benefits of sportfishing access to striped bass fishing in Maryland	Tobit, Heckman, Cragg (OLS for comparison)
Grogger & Carson (1991)	Recreational fishing trips in Alaska	Truncated Poisson and negative binomial count model

Taking into account censoring or truncation in the sample requires specific estimators. With a truncated sample containing only values greater than zero for the dependent variable, a truncated Maximum Likelihood (ML) estimator generates consistent estimates. Some recreational demand studies applying the ML estimator are Smith (1988) or Kealy & Bishop (1986), see Table 17. However, interviewing only participants (*on-site*) implies a loss of information on non-participants, i.e. information on the factors which lead an individual not to participate in the recreational activity. Consequently, there is no way to predict changes in the numbers of participants when parameters in the system change (Bockstael et al., 1989). Moreover, missing information on the limit observations (non-participants) will prevent results from being efficient. This is the cost of having "only" a truncated sample.

Censored data are generally estimated with limited dependent variable models, see Table 17 for some examples. In existing literature, sample selection models such as the Tobit or the Heckman model are frequently applied. Another popular way of accounting for zeros in the dependent variable are Count Data Models.

In our sample, only a fraction of the randomly sampled anglers of the Canton of Ticino are likely to actually fish on the Ticino River, the area of analysis we are interested in. We are therefore faced with a dataset comprising a large amount of individuals with zero trips (dependent variable) to the Ticino River. In our sample consisting of 413 anglers, 116 individuals say that they do not take fishing trips to the Ticino River. Three alternative modelling strategies – the Heckman model, the Tobit model and the Count Data Model - were evaluated against the criteria of consistency with the theoretical properties of the behavioural model. The Heckman model, applied for the case study presented in chapter 5, is presented first, followed by the popular Tobit model and the appealing Count Data Model.

Sample Selection Model (Heckman model)

A very popular way for estimating recreational demand for participants when the sample contains information on participants and non-participants is presented by the two-step sample selection model due to Heckman (1979) (see for example Bockstael et al., 1990; Smith, 1988; Hellerstein, 1992a and 1992b). This approach aims at correcting the potential sample selection bias due to the non-randomness of the subsample of participants. In our analysis, the non-randomness stems from the fact that those anglers choosing to take angling trips to the Ticino River rather than to any other river are likely to have some unobservable characteristics, call it "energy", which drives them to choose the Ticino River for their angling activity. The "energy", given that it is unobservable, is included in the error term of the trip demand equation. In this case, OLS yields unbiased estimates only if the error term is not correlated with any of the explanatory variables. If the unobserved characteristics are instead positively (negatively) correlated with an explanatory variable of the trip demand model, then the error term is correlated with the explanatory variable, and a possibly incorrect higher (lower) impact on the trip demand is ascribed to this variable.

The Heckman model is appealing because its two-step procedure reflects the individual's decision-making process: first, the *choice decision* of an individual to take angling trips to the Ticino River versus not taking any angling trips to the Ticino River is modelled. Second, the *frequency decision* is modelled for the given sample of anglers who take angling trips to the Ticino River[44]. The fundamental idea of the Heckman model in order to account for the potential sample selection bias is to introduce a new explanatory variable in the estimation of the frequency decision, obtained from the individual's choice decision. This new variable is supposed to account for the unobserved characteristics ("energy").

More precisely, this variable represents the value of the expected error of an angler being in the restricted sample of anglers taking trips to the Ticino River and is commonly called Inverse Mill's Ration (*IMR*) or *lambda*. *Lambda* is obtained from the first step probit estimator modelling the *choice decision* which explains the binary decision of taking angling trips to the Ticino River versus not taking any angling trips to the Ticino River as a function of some individual explanatory variables, z_i. The choice variable (*ChoiceT*) is an index variable for an underlying latent variable, *d*, for example the desire to angle on the Ticino River. If *d* lies above an individual threshold value, *d**, the individual is seen to take at least one angling trip to the Ticino River, and the index variable *ChoiceT* takes on the value 1.

Formally,

$$ChoiceT_i = 1 \quad \text{if} \quad d_i = \beta z_i + v_i > d^* \qquad (5.10a)$$

and

$$ChoiceT_i = 0 \quad \text{if} \quad d_i = \beta z_i + v_i \le d^* \qquad (5.10b)$$

[44] Recall that our total sample consists of 413 anglers, of which 297 make angling trips to the Ticino River.

Then, the probit model[45] estimates the probability of an individual angler choosing to take angling trips to the Ticino River (*choiceT*=1) (see Cameron, 1992, for details):

$$\Pr(choiceT = 1) = \Phi(\beta z_i / \sigma) \qquad (5.11a)$$

and not taking any angling trips on the Ticino River:

$$\Pr(choiceT = 0) = 1 - \Phi(\beta z_i / \sigma) \qquad (5.11b)$$

From the probit maximum likelihood (ML) coefficients, *lambda* is computed for each observation in the selected sample in the following way (see Puhani, 2000; or Greene, 2000):

$$\lambda_i (\frac{\beta z_i}{\sigma}) = \frac{\phi(\beta z_i / \sigma)}{1 - \Phi(\beta z_i / \sigma)} \qquad (5.12)$$

where ϕ is the density function for the standard normal and Φ is its cumulative density function (see Kennedy, 1998).

The *IMR* is a continuously decreasing function of the estimated probability of being a participant (5.10a), *Pr(choiceT*=1) (Heckman, 1979). This is intuitively plausible: if the probability of an individual choosing to take angling trips on the Ticino River given his observed characteristics is low, the expected value of the error term (*lambda)* is high and represents the unobserved "energy" which drove the individual to choose the Ticino River. Hence, if the probability is high, the expected value of the error (*lambda*) is low. Including *lambda* as an additional explanatory variable in the OLS frequency estimation accounts for the omitted variable bias, since it reduces the correlation of the error term with some explanatory variable.

The *frequency decision* models the number of trips, given the decision to choose the Ticino River for the angling activity, as a function of the individual explanatory variables, x_i, and *lambda*.

Formally, we have:

$$Trips_i (Trips_i | ChoiceT_i = 1) = \beta x_i + \delta \lambda_i + u_i \qquad (5.13)$$

where u_i is a normally distributed error term. Most econometric packages such as *Limdep* have standard procedures for the two-stage sample selection Heckman model.

Hence, the correlation coefficient (or covariance) between the two equations' error terms, *lambda*, distinguishes the sample selection model from just a simple regression and a probit model. If the errors *v* and *u* were uncorrelated, a simple OLS estimator could be used to estimate the frequency decision, ignoring the selection equation. If there is a very high rate of participation among the population, there will be a huge amount of small individual *lambdas* (standing for little correlation) and OLS estimates will not be too bad. The sample selection

[45] The role of the error term in qualitative dependent variable models such as probit or logit is not obvious. An error term is not necessary to provide a stochastic ingredient because for each observation the value of the dependent variable is generated via a chance mechanism embodying the probability provided by the functional equation of the normal (probit) or logistic (logit) distribution. Despite this, it is possible to conceptualize an underlying model that does contain an error term. For example, the Heckman sample selection model specifies an unobserved (latent) index variable as a linear function of explanatory variables and an error term (i.e. $X\beta + \varepsilon$). If this index exceeds a critical value, then y=1, otherwise y=0. More formally, $prob(y = 1) = prob(X\beta + \varepsilon > 0) = prob(\varepsilon > -X\beta)$ which is a cumulative density. If ε is distributed normally this is the cumulative density of a normal distribution and we have the probit model; if ε is distributed such that its cumulative density is a logistic function, we have the logit model. For further details, and also technical details on the logit/probit model, see Kennedy (1998).

problem is instead most severe when there is a very low participation rate and consequently a large number of large *lambdas* (i.e. a high correlation of error terms).

Since heteroskedasticity may be present in the disturbances when OLS is used with *lambda* as one of the predictors, Heckman (1976) suggests generalised least squares estimation to adjust standard errors in order to correctly judge the significance of coefficients.

Other frequently applied approaches to account for limited dependent variables are the Tobit model or the Count Data Model. The Tobit is a special case of the Heckman sample selection model, while Count Data Models have the appealing feature of representing data more naturally, since its distribution is defined for non-negative integers.

Tobit

The Tobit model[46] has the following data structure:

$$y_i = y_i^* \quad \text{if} \quad y_i^* > c \qquad (5.14a)$$

$$y_i = 0 \quad \text{if} \quad y_i^* \leq c \qquad (5.14b)$$

where y^* is the latent dependent variable. That is, for the individuals in the sample only those values of y^* are recorded which are greater than a constant c. For those values of $y^*<c$, the value c is recorded. y^* is assumed to have a normal distribution.

Although the Tobit can be shown to be a special case of the Heckman model, the two models have a quite different focus of interest. Whereas the Tobit model was designed to deal with estimation bias associated with censoring, the Heckman model is a response to sample selection bias (Sigelman & Zeng, 1999). The standard Tobit model assumes, among other things, that the dependent variable is censored at zero. Hence the standard Tobit specification is inappropriate if the zeros in the dependent variable are not the result of censoring. In fact, the zero values in the sample of recreational anglers are not due to nonobservability (i.e. because values below zero have been censored), but are a result of a decision that produces the zero observation (Maddala, 1992). However, this point is often ignored: there are many applications of the Tobit model in recreation demand analysis (e.g. Bockstael et al., 1990; Layman et al., 1996; Smith, 1988). Clearly, applying a model to data which violate the model's main assumptions could result in incorrect inferences.

However, even if the Tobit model is applied to genuinely censored data, there are considerable limitations to this approach.

First, in the Tobit model the discrete choice and the continuous frequency decisions are essentially driven by the same underlying model for tastes. This means that a variable that increases the probability of an observation being a non-limit observation also increases the mean of the variable. This is the key behavioural aspect of the Tobit model, which represents at the same time an important limit. In fact, it implies that the same characteristics that cause anglers to choose a specific angling site also influence the intensity of their angling. Hence, the coefficients of these characteristics have the same sign and magnitude (Bockstael et al., 1990). However, different factors may influence choice and frequency decisions and a given factor

[46] The Tobit takes its name from the probit Tobin devised. In a probit model, the variable of theoretical interest, y^*, is unobserved; what is observed is a dummy variable, y, which takes on a value of 1 if y^* is greater than 0 and 0 otherwise. Tobin (1958) devised the censored normal regression model for situations

might have opposite effects on the two decisions. Think for example of pensioners. They might be more likely to be anglers, but they might take less angling trips because of a variety of reason, such as age, health etc.

Another important problem is Tobit's sensitiveness to specification errors and distributional assumptions. If the assumption of a normal and homoskedastic error term is violated, Tobit produces biased estimates (Maddala, 1983).

Another obstacle to a correct use of the Tobit model is its somewhat complicated interpretation of estimation results. We are interested in the marginal effects of the independent variables on the dependent variable. However, while in OLS coefficients directly represent marginal effects, the Tobit model has three marginal effects expressions, depending on the focus of interest (see Greene, 2000; Sigelman & Zeng; 1999). The marginal effect of an explanatory variable on the latent dependent variable could be of interest if one wants to know about the underlying propensity to take recreation trips; marginal effects on the observed dependent variable might be useful to understand determinants of actual trips by participants and non-participants; while marginal effects on the censored dependent variable helps understand recreation demand by participants alone.

Count Data Models

Count Data Models (Cameron & Trivedi, 1998) present a perhaps more natural way of accounting for non-participants. These models have become prominent lately in the analysis of recreation demand since they reflect the count data nature of recreation trips (Hellerstein, 1992a; Creel & Loomis, 1990; Hausman et al., 1995; Cameron & Trivedi, 1986). In fact, these models differ from other limited dependent variable models such as Tobit or Heckman in that the data generating process is assumed to produce only non-negative integer values. However, Count Data Models still have to account for sample selection bias in the presence of samples from on-site surveys with users only. In this case, the estimator has to be adapted to truncation.

The standard model for count data is the Poisson regression model, a nonlinear regression model. Under the Poisson probability distribution it is impossible to observe a fractional or a negative outcome. However, zero outcomes are allowed (Creel & Loomis, 1990; Hellerstein, 1992b).

The Poisson distribution[47] is defined by a single parameter λ, where λ equals both the mean and the variance of the distribution[48]. λ can be interpreted as the expected number of trips during a given period of time. Since the Poisson is defined only for positive values of λ, λ is usually modelled as an exponential function $\lambda = \exp(X\beta)$, with X a vector of exogenous variables and β the vector of parameters to be estimated (Hellerstein, 1992b).

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in which y is observed for values greater than 0 but is not observed for values of zero or less (Sigelman & Zeng, 1999).

[47] The Poisson probability density function is given by (see for example Haab & McConnell, 2002):

$$\Pr(x_i = n) = \frac{\exp^{-\lambda_i} \lambda_i^n}{n!}, \text{ n=0,1,2,...}$$

[48] Given the fact that the equality-stringency between mean and variance has often been found to be violated in recreational data, in practice generalized count models are often applied (Haab & McConnell, 2002). For example, the Negative Binomial Model allows the variance to vary freely.

The match between distributional assumptions of Count Data Models and observed data suggests that count models may be inherently superior to the more familiar continuous distribution-based estimators for estimating recreational demand (Hellerstein, 1992b). However, while the Poisson distribution is noticeably asymmetric for low mean values, it approximates a normal distribution when the mean value λ is large (or moderately high). The implication is that the normal distribution approach should be used for high counts, whereas low counts can be better analysed by the Poisson distribution.

Count Data Models also have some econometric advantages. In general terms, Count Data Models are robust to mis-specification and are flexible in terms of error structure. This compares favourably with the case of Tobit or similar estimators which are biased when the actual distribution is not normal.

Choice of estimator

In sum, we can say that Count Data Models are appealing for a variety of reasons, which has given rise to many applications of this approach to environmental valuation based on recreation analysis. However, where the probability of an event occurring is small and the mean *(λ)* is high, the Poisson distribution approximates the normal[49], and therefore continuous models relying on a normally distributed error should be applied. Given relatively high mean trip values which range in our case from between 26 and 36 trips for the actual and the hypothetical situation respectively, it seems reasonable to apply continuous models and to concentrate on the choice between Tobit and Heckman models.

Bockstael et al. (1990) state that the choice between the Tobit and Heckman sample selection models relies on the model's behavioural implications as well as its statistical properties and is particularly critical when the ultimate goal is the calculation of welfare measures. The behavioural aspect considers whether the theoretical and statistical properties of the model are consistent with individual data on behaviour (for example accommodation for zero trips). While the behavioural implications can be studied theoretically, the econometric performance of the model (theoretically expected signs, statistical significance of the variables, and explanatory power of the estimated model) is an empirical matter.

From a behavioural perspective, the Heckman two-step model has intuitive appeal, since its model structure reflects actual individual decision-behaviour. For example, the recreational angling demand on the Ticino River can be assumed to be the result of two decisions: initially, an angler decides to choose the Ticino River for angling trips rather than any other river in the Canton of Ticino. The second decision is about frequency, i.e. the number of trips during an angling season, given that the individual chooses the Ticino River for his angling activity.

An interesting feature of the Heckman model, not present in the Tobit model, is that it allows different factors and different error structures to affect the choice and the frequency decisions. In fact, it might be plausible to think of factors such as health, age, angling skills or others to be necessary for an individual to take angling trips on the Ticino River, if for example it is assumed that these angling sites are difficult to access and need some physical force (Bockstael et al., 1989). An individual who is not responsive to prices because of these factors ought not to be in

[49] This is because of the Central Limit Theorem (see for example Greene, 2000), which says that regardless of the underlying distribution, as the number of observations approaches infinity, the distribution converges to the normal distribution.

the sample for demand function estimation (Haab & McConnell, 2002). Technically, the probability of a limit observation is independent of the regression model for the nonlimit data.

These are the reasons that motivated our decision to use the sample selection model proposed by Heckman.

5.3.6 Functional Form

The functional form defines the way in which the dependent variable is related to the independent variables in the specification of recreation demand equations. The choice between functional forms is not straightforward and there is no conclusive empirical evidence on the best form to be applied. However, it is recommendable to give consideration to this choice, given that different functional forms are likely to produce dramatically different consumer surplus estimates (Ziemer et al., 1980; Adamowicz et al., 1989).

In existing empirical literature, the most frequently applied functional forms to model recreation behaviour are the linear, the semi-log[50] (Graham-Tomasi et al., 1990), with a tendency for the semi-log functional form to preponderate (Ozuna et al., 1993). Hence, the attention in this discussion will lie on these two functional forms.

In the *linear functional form*, the number of trips to a given site is a function of a number of variables related in a linear way to the trips. In a simplified model with only one explanatory variable, this is:

$$trips = \alpha + \beta TC \tag{5.15}$$

where α and β are the parameters to be estimated by the econometric model, TC are the individual travel costs incurred to reach the site, and trips is the number of recreation trips to a specific site.

With the *semi-log functional form,* the relationship between the dependent and independent variables is of the following form:

$$\ln trips = \alpha + \beta TC \tag{5.16}$$

where ln*trips* stands for the natural logarithm of the number of trips.

These functional forms often fit the data well (Ziemer et al., 1980) and have desirable theoretical properties. The linear form is easy to estimate, although less flexible than non-linear functional forms. The semi-log seems to adapt better to the data if the sample includes individuals with just a few trips associated to high travel costs and/or of a high number of trips with very low travel costs.

The choice of the appropriate functional form is predominantly an empirical matter (Garrod & Willis, 1999). Economic theory provides little guidance, although it is fundamental in the formulation of economic hypotheses which are compared to empirical results. The consistency of estimation results with theoretical expectations can be tested by a simple *t*-test testing the statistical significance of the variables of the model and by comparing the estimated coefficient's sign to the expected direction of impact.

[50] A further less frequently applied specification is the double-log. Graham-Tomasi et al. (1990) however do not recommend the double-log form for applied work since it can be questioned on the grounds that it is not integrable, implying that recreation is an essential good.

Moreover, economic theory can tell if the economic implications of the different functional forms comply with economic theory. The underlying assumptions implicit in the functional forms should reflect the reality to be modelled. In the recreation behaviour case however, the linear functional form predicts negative trips for high travel costs, while the semi-log functional form implies that no price, however high, will drive trip demand to zero. The economic hypotheses implicit in the functional forms can easily be illustrated by depicting them graphically:

Figure 10 depicts the linear case, with the horizontal axis representing the number of angling trips, and the vertical axis depicting the average travel costs. Suppose that an empirical analysis resulted in the plausible inverse relationship between angling trips and average travel cost. This implies finite trips at zero costs but as costs per trip increase, the number of trips decreases, and eventually becomes negative. In this case where the model predicts negative trips, the interpretation of empirical results proves difficult.

Figure 10 - Linear demand function

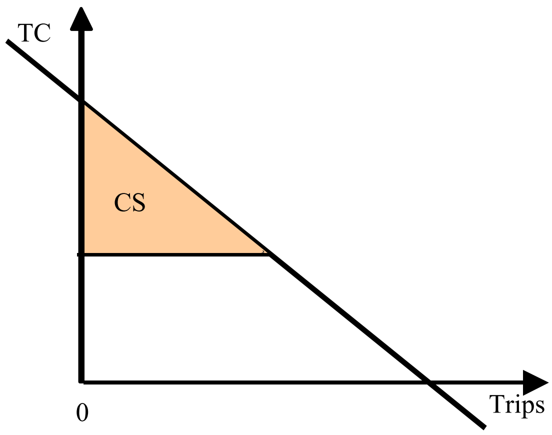
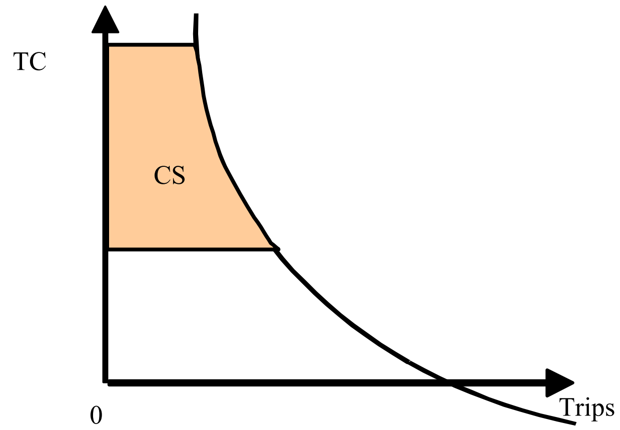


Figure 11 shows a semi-log functional form which implies a finite number of visits at zero costs and never predicts negative visits even at very high costs. This property that no price however high reduces trips to zero led to the suggestion of cutting off unrealistic high travel cost values by introducing a “choke price”, that is a price which drives demand to zero, for example the maximum travel cost observed in the sample (Adamowicz et al., 1989).

Figure 11 - Semi-log demand function



Having considered the economic implications, the choice between functional forms must ultimately rely on econometric criteria and result sensitivity. The basic econometric criteria for the choice of the functional form include computational or analytical ease, the percentage of the variation in the dependent variable explained by the independent variables, i.e. the measure for overall fit of the model (R^2), the overall significance of the model (*F*-statistic), statistical significance of the single variables (*t*-statistic), and the comparison of predicted with actual outcomes (Adamowicz et al., 1989; Garrod & Willis, 1999).

In sum, to judge a Travel Cost Model it seems that statistical reliability together with the consistency of the results with other similar studies are the best support for a given specification (Garrod & Willis, 1999).

5.3.7 Increase in Consumer Surplus for a low flow enhancement

Given the specification of the recreation demand model, demand parameters are estimated which can be used to calculate marshallian Consumer Surplus (*MCS*) measures. In existing empirical literature, the most commonly applied procedure consists in calculating the area under the marshallian demand curve by integrating the estimated demand function from individual's average travel cost (TC_{mean}) up to the choke price which drives individual's demand to zero (TC_{max}) (see for example Bockstael et al., 1990)[51]. Note that the choke price is implied in the linear functional form but has to be imposed in the semi-log functional form (see section on functional forms and discussion that follows).

In general terms, the *MCS* is:

$$MCS = \int_{TCmean}^{TC\max} x(tc, q, y)dtc \tag{5.17}$$

[51] Another approach proposed by Tempesta (1995) is to sum up the prices corresponding to each number of trips, since we are dealing with discrete trips: $SC_i = \sum_{i=1}^{n} p_i - p_n n$ with $p_i = f(g_i)$, where p_i is the price at which the number of trips g_i are taken and n is the number of trips taken in one angling season.

Figure 12 – Consumer Surplus

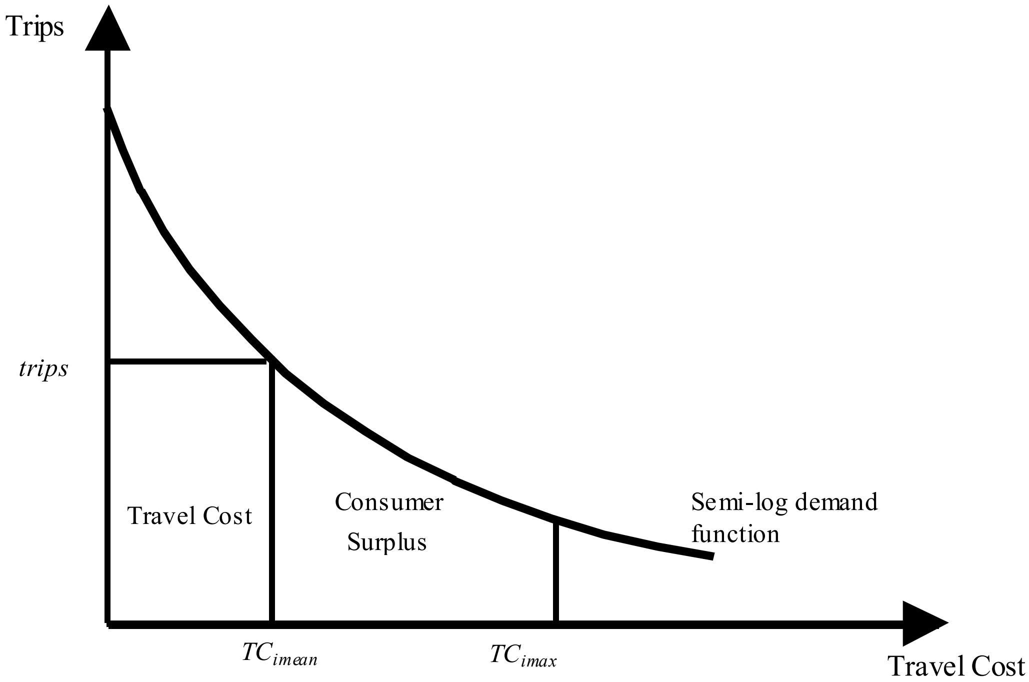
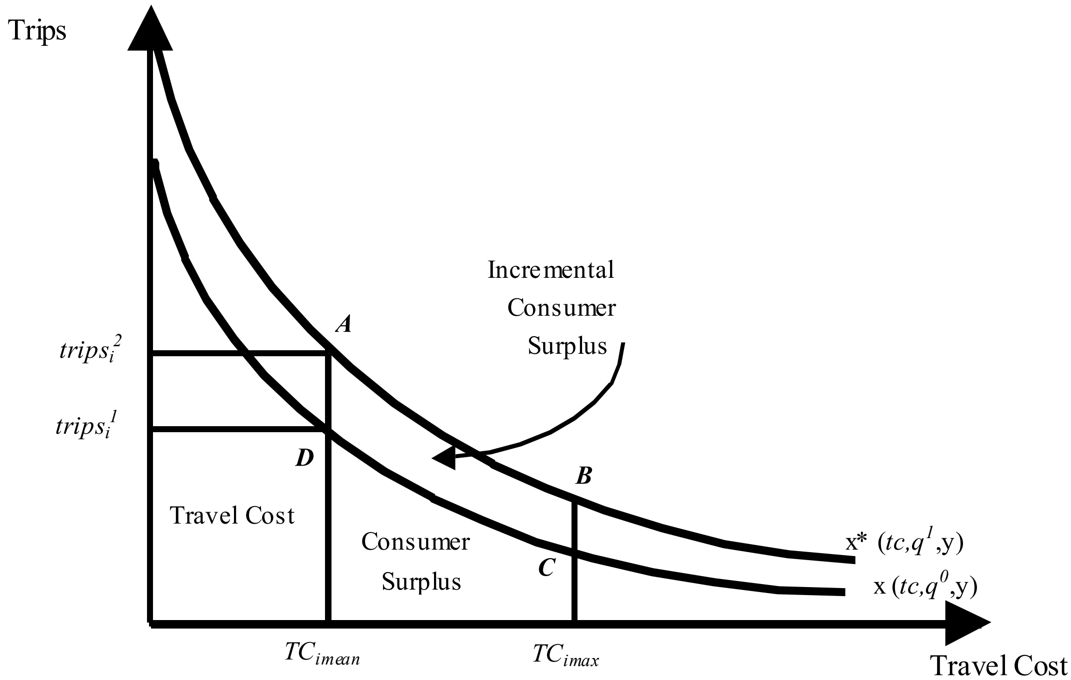


Figure 12 illustrates a semi-log demand function for recreational angling trips, with individual travel costs on the horizontal axis, and the number of individual's seasonal angling trips on the vertical axis. The inversion of the axis with respect to the traditional representation used up to this point is only applied to enhance clarity and does not alter results. Moreover, Figure 12 depicts a semi-log demand function only in order to keep the graphical presentation as simple as possible. Empirical results presented further down however refer to both the linear and the semi-log function forms.

Figure 13 is an extension of Figure 12, including the rightward-shifted recreational angling demand function $x^*(tc,q^1,y)$ resulting from a quality improvement. Thus, the welfare effect of a low flow alleviation corresponds to the area delimitated by *ABCD* which is simply the difference in *CS* before and after the quality improvement. Given the quality improvement, the *CS* is, (analogously to the *CS* of the actual situation) simply the area under the quality improved demand curve x^*.

Figure 13 - Increase in Consumer Surplus due to a low flow enhancement



Consequently, the welfare effect of a quality improvement can formally be expressed as (see also Layman et al., 1996):

$$\Delta MCS = \int_{TCmean}^{TC\max} x^*(tc, q^1, y)dtc - \int_{TCmean}^{TC\max} x(tc, q^0, y)dtc \quad (5.18)$$

where x^* represents the recreation demand after the quality improvement and x is the demand given the actual situation.

This integral (5.18) can be simplified in two formulas for either functional form respectively. Let us illustrate the formulas for the simplified deterministic model containing only two explanatory variables, that is travel costs *TC*, and a dummy variable capturing the effect of the quality change on trips, *DHS*. Thus, in the linear case, we have:

$$trips = \alpha + \beta TC + \gamma DHS \quad (5.19)$$

and in the semi-log case, where the natural logarithm is taken on the number of trips:

$$\ln(trips) = \alpha + \beta TC + \gamma DHS \quad (5.20)$$

α, β and γ are the parameters which will be estimated by the econometric model,

For the linear functional form, equation (5.18) collapses to the following expression (see for example Graham-Tomasi et al., 1990, Haab & McConnell, 2002)[52]:

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[52] The derivation goes as follows (Haab & McConnell, 2002):

$$CS = \int_{TCmean}^{TC\max} (\alpha + \beta TC)dTC = \alpha TC_{\max} + \frac{\beta TC_{\max}^2}{2} - \left[\alpha TC_{mean} + \frac{\beta TC_{mean}^2}{2}\right]$$

The following simplifications holds for any *TC*:

$$\alpha TC + \frac{\beta TC^2}{2} = \frac{2\alpha\beta TC + \beta^2 TC^2}{2\beta} = \frac{(\alpha + \beta TC)^2}{2\beta} - \frac{\alpha^2}{2\beta}$$

$$\Delta MCS = \frac{(\alpha + \beta TC_{mean} + \gamma)^2}{-2\beta} - \frac{(\alpha + \beta TC_{mean})^2}{-2\beta} \tag{5.21}$$

The first term on the right hand side stands for the *CS* given the improved quality situation, distinguished by *γ*, the parameter estimate of the demand-shifter *DHS*. The second term is the *CS* measuring the welfare of the previous quality state. The statistical significance of the change of *CS* can be examined with a *t*-test on the dummy variable *DHS* which captures the effect of the quality improvement on the trip demand.

Analogously for the semi-log model where the natural logarithm is taken on the number of trips, equation (5.18) simplifies to[53]:

$$\Delta MCS = \frac{\exp(\alpha + \beta TC_{mean} + \gamma)}{-\beta} - \frac{\exp(\alpha + \beta TC_{mean})}{-\beta} \tag{5.22}$$

It has already been pointed out that *CS* estimates vary enormously depending on choices made on several issues concerning model specification and estimation. Further, *CS* values are sensitive to choices regarding the computation procedure, such as

- the definition of a choke price which drives demand to zero (truncation);
- the choice between actual and predicted trips.

These issues have to be addressed when computing *CS* for the linear and the semi-log functional form.

Consider first the issue of the choke price. Given that the semi-log functional form has no finite positive TC_{max} which drives demand to zero, most empirical *TC* studies apply a choke price which truncates the open end of the demand curve at a reasonable value of the travel cost, as presented in Figure 13. Often, the maximum travel cost observed in the sample is used. Therefore, the *CS* formula for the semi-log form is:

$$\Delta MCS = \frac{\exp(\alpha + \beta TC_{\max} + \gamma)}{-\beta} - \frac{\exp(\alpha + \beta TC_{mean} + \gamma)}{-\beta} - \left[\frac{\exp(\alpha + \beta TC_{\max})}{-\beta} - \frac{\exp(\alpha + \beta TC_{mean})}{-\beta}\right] \tag{5.23}$$

By definition, $\alpha + \beta TC_{\max} = 0$, and $\alpha + \beta TC_{mean} = Trips$

Upon evaluation and rearranging, the first equation for *CS* becomes

$$CS = -\frac{trips^2}{2\beta}$$

[53] In the semi-log case (Haab & McConnell, 2002), the choke price TC_{max} is infinite. To see this, consider the simple demand specification $\ln(trips) = \alpha + \beta TC$. It is immediately clear, that, for any finite *TC*, $trips = \exp(\alpha + \beta TC) > 0$, i.e. no finite *TC* drives trips demand to zero.

Then, the derivation is:

$$CS = \int_{TCmean}^{\infty} e^{\alpha + \beta TC} dTC = \left[\frac{e^{\alpha + \beta TC}}{\beta}\right]_{TCmean}^{TC\max\to\infty} = -\frac{trips}{\beta}$$

Although not necessary from a computational point of view, the linear functional form can also be truncated at TC_{max}, as suggested by Adamowicz et al. (1989). In fact, the linear functional form implies a finite positive value of travel costs associated to zero demand for recreational angling trips. However, the implicit price which drives the linear demand to zero might lie outside the range of observed values in the sample and therefore may not be very realistic (i.e. higher than the maximum travel cost observed in the sample). Hence, truncated *CS* in the linear case is:

$$\Delta MCS = \frac{(\alpha + \beta TC_{\max} + \gamma)^2}{-2\beta} - \frac{(\alpha + \beta TC_{mean} + \gamma)^2}{-2\beta} - \left[\frac{(\alpha + \beta TC_{\max})^2}{-2\beta} - \frac{(\alpha + \beta TC_{mean})^2}{-2\beta} \right] \quad (5.24)$$

Consider now the choice between actual and predicted trips. The *CS* formulae presented above apply predicted trips for the computation of the welfare measure (predicted actual trips: $\alpha + \beta TC$; predicted hypothetical trips: $\alpha + \beta TC + \gamma$). However, there is no a priori reason for using predicted instead of actual trips. Since this has important implications on the recreation benefit estimates, the *choice between actual and predicted trips* is important, particularly when it is for public policy decision purposes that recreational demand analysis is undertaken.

Bockstael & Strand (1987) and Bockstael et al. (1990) point out, that this choice depends on the assumption regarding the source of the stochastic error term in the demand equation. In most econometric applications, the source of the disturbance term or "error" is immaterial, as long as the Gauss-Markov assumptions hold. These conditions are sufficient to produce unbiased and efficient estimates. However, if the ultimate purpose of the estimation exercise is to compute consumer surplus estimates, then the story does not end here.

The stochastic term in econometric models may arise from several sources and can be classified in the following way (Bockstael & Strand, 1987; Bockstael et al., 1990):

- *Omitted variables*: factors which influence recreational demand have not been introduced and thus error-free explanation of demand is not possible;
- *Random preferences and human indeterminacy*: behaviour, even with all explanatory variables included and measured perfectly, cannot be predicted because of inherent randomness in preferences;
- *Measurement error in the dependent variable*: the recall of the annual number of recreational trips might be subject to error, making the exact measurement of the dependent variable impossible.[54]

[54] Measurement error can also occur in the independent variables, when travel expenses for example are not recalled with precision. However, only omitted variables, human indeterminacy and measurement error in the dependent variable are sources of error conforming to the Gauss-Markov assumptions, and then only if the omitted variables are assumed to be uncorrelated with included variables. Measurement error in explanatory variables violates the assumed independence between the error and explanatory variables. In this case, estimation techniques such as instrumental variables are frequently employed. However, these methods will generate different coefficient estimates from the other three. As such, meaningful comparisons are nearly impossible to make. The discussion is thus restricted to considerations

As Bockstael & Strand (1987) point out, there are good reasons for choosing either the actual observed trips or predicted trips in the computation of the *CS*. They argue that it is basically the source of the stochastic term, which determines whether to use observed or predicted trips in the computation of *CS*. If the researcher believes that most of the error implicit in u_i is due to omitted variables, then the observed actual trips (x) might give better consumer surplus estimates. However, in recreational surveys where recall error often abounds, u_i may reflect measurement error in the dependent variable. If this predominates, or if the individual has random preferences, the predicted quantity may be more reliable. In fact, if the consumer has random preferences, then one cannot be certain that the observed value of x will be chosen by the *ith* individual each time the same price-income situation arises. The "best guess" at the level of x consumed by the individual facing the price-income situation (p,y) is the systematic portion of demand. When the error occurs because the individual cannot remember the exact number of trips, then once again the best guess of the actual number of trips is the systematic demand (Bockstael & Strand, 1987). In short, in the first case, actual observed trips should be used, while in the other cases, predicted values would be appropriate.

Hence, given that alternative interpretations of the error term in the demand equation influence *CS* estimates, the application of the coefficients obtained by valid estimators to the computation of consumer surplus is not necessarily straightforward.

Once decided on the source of error, with censored samples *predicted trip values* must be obtained in the following way (Bockstael & Strand, 1987; Maddala, 1983; Bockstael et al., 1990):

1) For the anglers who take fishing trips to the Ticino River (i.e. observations in the selected sample), the predicted trips are given by:

$$E(trips_i \mid choiceT_i = 1) = \beta' x_i + E(u_i \mid u_i > -\beta' x_i)$$

$$E(trips \mid choiceT_i = 1) = \beta' x_i + \sigma \frac{\phi_i}{\Phi_i} \tag{5.25}$$

where ϕ and Φ are the density function and the cumulative distribution function of the standard normal evaluated at $\beta' x_i / \sigma$ and σ is the standard deviation of the standard normal.

This formula yields predictions of the mean of the number of positive trips for anglers who visit the Ticino River.

2) For the whole angling population of the Canton of Ticino, the expected number of trips is:

$$E(trips_i) = P(trips_i > 0) * E(trips_i \mid choieT_i = 1) + P(trips_i = 0) * E(trips_i \mid choiceT_i = 0)$$

$$= \Phi_i (\beta' x_i + \sigma \frac{\phi_i}{\Phi_i}) + (1 - \Phi_i) 0$$

$$E(trips_i) = \Phi_i \beta' x_i + \sigma \phi_i \tag{5.26}$$

This formula gives predictions of the mean of all observed trips, positive and zero.

of the first three sources of error and the error is assumed independent of included variables (Bockstael et al., 1989).

5.4 Recreational benefits of a river flow alleviation: empirical results

5.4.1 Econometric model

Finally, putting together the pieces of the puzzle, the Hypothetical Travel Cost Heckman model is specified in the following way:

The first step of the two-step Heckman model consists in the *probit model* estimating the probability of an angler choosing the Ticino River for angling trips (5.27):

$$\begin{aligned}\Pr(ChoiceT = 1) = \Phi\big[(&\alpha + \beta_P P_{iT} + \beta_{PLake} PLake_{il} + \beta_{DHS} DHS_i \\ &+ \beta_{DY1} DY1_i + \beta_{DY2} DY2_i + \beta_{DY3} DY3_i + \beta_{DPens} DPens_i \\ &+ \beta_{DPeriod} DPeriod_i + \beta_{DHol} DHol_i + \beta_{DHH} DHH_i + \beta_{DGroup} DGroup_i \\ &+ \beta_{DPond} DPond_i + \beta_{DCar} DCar_i + \beta_{DSC} DSC_i + \beta_{DLoc} DLoc_i)/\sigma\big]\end{aligned} \tag{5.27}$$

where Φ is the cumulative density function and σ represents the standard error.

The second step of the Heckman model models the frequency decision conditional on the choice of taking angling trips to the Ticino River in a *simple OLS* framework, specifying the relationship between the dependent variable and the independent variables in a linear (5.28) and semi-log functional form (5.29):

$$\begin{aligned}trips_{iT}^{k} = &\alpha + \beta_P P_{iT} + \beta_{PLake} PLake_{il} + \beta_{DHS} DHS_i \\ &+ \beta_{DY1} DY1_i + \beta_{DY2} DY2_i + \beta_{DY3} DY3_i \\ &+ \beta_{DPens} DPens_i + \beta_{DPeriod} DPeriod_i + \beta_{DGroup} DGroup_i + \beta_{Lambda} Lambda_i + u_i\end{aligned} \tag{5.28}$$

$$\begin{aligned}\ln(trips_{iT}^{k}) = &\alpha + \beta_P P_{iT} + \beta_{PLake} PLake_{il} + \beta_{DHS} DHS_i \\ &+ \beta_{DY1} DY1_i + \beta_{DY2} DY2_i + \beta_{DY3} DY3_i \\ &+ \beta_{DPens} DPens_i + \beta_{DPeriod} DPeriod_i + \beta_{DGroup} DGroup_i + \beta_{Lambda} Lambda + u_i\end{aligned} \tag{5.29}$$

where u_i denotes the independent identically distributed (i.i.d.) error term, which is assumed to be normally distributed with mean of zero and constant variance.

Note that in the frequency decision, the additional variable lambda is included to correct for the non-randomness of the sample of fishermen who choose to fish on the Ticino River. Note moreover, that different variables specify the choice and the frequency decision. This is an important advantage of the Heckman model over the Tobit model, since it enables us to explain the participation decision by factors other than the frequency decision. Actually, the inclusion of variables in the first step choice decision in addition to those in the frequency decision can be important for identification in the second step. The problem is that when the explanatory variables of the two steps are identical, the Heckman model is only identified by the fact that *lambda* is a nonlinear function. Empirically, the two-step approach will therefore not work very well if there is little variation in *lambda* and *lambda* is close to being linear in the explanatory variables of the participation equation (Verbeek, 2000).

5.4.2 Coefficient estimates

This section presents the parameter estimates of the econometric model specified above for

- (A): the whole Ticino River;

and two of its sub-regions,

- (B): the Leventina & Blenio area;
- (C): the Leventina area.

For the definition of the areas, see section 5.1 or the map of the angling zones in Appendix 5 and the definition of areas in Appendix 6.

The decision to present the results of the two sub-regions together with the results for the whole Ticino River was taken on the grounds of the following considerations: In order to estimate the recreation demand to the Ticino River as a single demand equation, quality variables need to be included in the demand equation which account for the qualitative heterogeneity of the angling sites on the Ticino River. Not including quality variables imposes the strong hypothesis of homogeneous quality conditions along all the sites of the Ticino River. However, no adequate information on water flow quantity was available to be included in the model. An approximate solution would consist in introducing region dummies, together with interaction terms allowing for different slopes in the demand curves. However, given that the dependent variable "number of trips" is the sum of the total number of trips taken to three different sites on the Ticino River, it was not possible to assign site dummies. For this reason, we decided to split the Ticino River into smaller, supposedly more homogeneous areas in terms of low flows.

The following tables present the results of the econometric model estimation, which were computed with the econometric package Limdep 7.0. Table 18 reports the probit model of the two-stage Heckman model, explaining the selection of the sample of anglers who take angling trips to the Ticino River out of the whole sample of anglers, while Table 19 and Table 20 present OLS parameter estimates for the frequency decision model. Recall that this procedure was chosen since in the econometric model estimation we are interested in the Ticino River and its tributaries, while data was collected on the whole angling population of the Canton of Ticino. All anglers who do not visit the area under analysis appear therefore to take zero trips.

Table 18 – Heckman first stage probit, choice decision (*t*-values in brackets)

Coefficients	(A) Ticino River	(B) Leventina & Blenio	(C) Leventina
Intercept	2.19***	7.77***	6.55***
	(6.071)	(10.235)	(9.715)
TC	-0.023***	-0.11***	-0.10***
	(-6.347)	(-13.768)	(-13.530)
Tcalt	0.004	-0.02**	-0.015*
	(0.577)	(-2.056)	(-1.813)
DHS	-0.001	-0.04	-0.045
	(-0.009)	(-0.310)	(-0.366)
DY1	-0.39	-2.48***	-2.32***
	(-1.277)	(-5.667)	(-5.927)
DY2	-0.22	-1.62***	-1.48***
	(-1.086)	(-5.617)	(-5.713)
DY3	-0.13	-0.73***	-0.76***
	(-0.588)	(-2.598)	(-2.958)
Dpensioner	-0.04	-0.13	-0.20
	(-0.242)	(-0.665)	(-1.117)
Dperiod	-0.09	-0.05	0.055
	(-0.668)	(-0.291)	(0.352)
Dgroup	0.53***	0.64***	0.49***
	(4.515)	(4.459)	(3.760)
Dpond	-0.08	-0.13	0.14
	(-0.492)	(-0.629)	(0.737)
Dsottoceneri	-0.12	3.12***	2.85***
	(-0.543)	(11.954)	(11.743)
Dlocarnese	-1.47***	1.55***	1.46***
	(-6.679)	(5.405)	(5.263)
Dcar	-0.07	-0.25	-0.17
	(-0.509)	(-1.605)	(-1.141)
Dholiday	0.21	0.08	0.057
	(1.066)	(0.363)	(0.277)
Dhousehold	-0.04	-0.28*	-0.18
	(-0.319)	(-1.819)	(-1.314)
Likelihood Ratio	306.09***	684.27***	564.36***

*, **, *** statistically different from zero at a confidence level of 90, 95 and 99%

The results of the probit estimates in Table 18 are used for the computation of *lambda* correcting the non-randomness of the selected sample in the second stage OLS-estimation of the frequency decision. These results will not be discussed further, since they are not of primary interest. However, the Likelihood-Ratio Test (*LR*) (Greene, 2000), the pendant to the *F*-test for linear estimators, confirms the validity of the model specification.

An important step of the modelling strategy evaluation is the empirical verification of the theoretically expected signs and statistical significance of the variables. Table 19 and Table 20 present the estimation results of the frequency decision in the linear and semi-log specification, respectively. Consistent with the results of other studies, the estimation generally yielded the anticipated signs for the coefficient estimates and indicates in most cases the same effect for those variables for which we had no a priori expectations.

Table 19 – Linear Heckman second stage, frequency decision (*t*-values in brackets)

Coefficients	(A) Ticino River	(B) Leventina & Blenio	(C) Leventina
Intercept	32.18***	32.94***	34.11***
	(5.665)	(5.056)	(4.925)
TC	-0.22***	-0.31***	-0.28***
	(-3.532)	(-4.209)	(-3.698)
Tcalt	0.49***	0.35***	0.19**
	(5.251)	(3.705)	(1.974)
DHS	10.14***	8.10***	7.19***
	(4.649)	(3.587)	(3.028)
DY1	6.97	7.49	8.79
	(1.136)	(1.215)	(1.121)
DY2	5.23	1.83	3.71
	(1.232)	(0.452)	(0.853)
DY3	-2.87	-2.32	-1.49
	(-0.635)	(-0.542)	(-0.326)
Dpensioner	-5.23*	-5.90*	-2.71
	(-1.758)	(-1.787)	(-0.770)
Dperiod	-5.64**	-4.96*	-3.83
	(-1.971)	(-1.683)	(-1.242)
Dgroup	-4.83**	-1.74	-4.24
	(-1.960)	(-0.697)	(-1.629)
Lambda	-14.75***	-4.01	-5.01
	(-2.911)	(-1.271)	(-1.611)
Adjusted R^2	0.28	0.30	0.28
F-test	23.79***	17.85***	13.05***
	$F(10, 583)$	$F(10, 381)$	$F(10, 304)$

*, **, *** statistically different from zero at a confidence level of 90, 95 and 99%

Table 20 – Semilog Heckman second stage, frequency decision (*t*-values in brackets)

Coefficients	(A) Ticino River	(B) Leventina & Blenio	(C) Leventina
Intercept	3.16***	3.00***	3.19***
	(14.772)	(10.583)	(10.264)
TC	-0.008***	-0.011***	-0.012***
	(-3.296)	(-3.580)	(-3.514)
Tcalt	0.013***	0.011***	0.005
	(3.787)	(2.639)	(1.070)
DHS	0.39***	0.40***	0.38***
	(4.761)	(4.096)	(3.591)
DY1	0.30	0.26	0.51
	(1.300)	(0.971)	(1.454)
DY2	0.17	0.10	0.20
	(1.045)	(0.589)	(1.018)
DY3	-0.06	-0.10	-0.12
	(-0.379)	(-0.552)	(-0.609)
Dpensioner	-0.29***	-0.27*	-0.40***
	(-2.589)	(-1.893)	(-2.577)
Dperiod	-0.23**	-0.18	-0.17
	(-2.114)	(-1.435)	(-1.229)
Dgroup	-0.20**	-0.06	-0.17
	(-2.188)	(-0.584)	(-1.489)
Lambda (λ)	-0.84***	-0.37***	-0.42***
	(-4.694)	(-2.777)	(-3.086)
Adjusted R^2	0.30	0.28	0.31
F-test	26.59***	16.12***	14.89***
	$F(10, 583)$	$F(10, 381)$	$F(10, 304)$

*, **, *** statistically different from zero at a confidence level of 90, 95 and 99%

Before discussing single parameter estimates, some general comments on the estimation results presented in Table 18 and Table 19 are needed. In terms of statistical significance (*t*-values), an important econometric criterion in judging the validity of estimates, the whole Ticino River (A) seems to generate the best results for both the linear and the semi-log functional form. In fact, a part from the income dummy variables which were expected not to be statistically significant, all included variables appear to be relevant in the trip demand function. Concerning the other two areas under analysis, the Leventina&Blenio (B) and the Leventina (C), fewer variables compared to the Ticino River are statistically significant. Consider however, that the sample for estimating (A) is considerably larger than the samples for (B) and (C). Considering the *t*-values, the results give no clear-cut picture indicating which functional form to prefer.

The *F*-test[55], which indicates whether the estimated equation as a whole has acceptable predictive ability, also favours the results from the Ticino River over the smaller regions for both functional forms.

Regarding the percentage of the explained variance we see that the *adjusted* R^2 is generally quite low, ranging between 0.25 and 0.31. Note however that it is difficult to obtain high values for the *adjusted* R^2 in the estimation of models with individual cross-section data. For an analogous result regarding the *adjusted* R^2 see Layman et al. (1996).

The variable characterising the Travel Cost Model is the travel cost variable (*TC*). As expected, its coefficient results to be the most consistent determinant of the demand for each site's services. This coefficient is moreover fundamental for the benefit estimation, depending largely on the price parameter. The *TC* coefficient turns out to be negative and significantly different from zero throughout the model results presented, reflecting the fact that with an increase of the travel cost the number of trips decreases. However, the linear and the semi-log specifications do not give the same picture of the size of impact of the travel cost on the number of trips in a season. In fact, if in the linear case the highest negative impact is given in the Leventina&Blenio case, followed by the Leventina and the Ticino River, in the semi-log specification the order is different, with the highest negative impact in the Leventina, followed by Leventina&Blenio and the Ticino River. However, given that this is not the only determining factor, from these results nothing can yet be said on the relative sizes of *CS*.

The coefficient of the travel cost variable to a substitute angling site on a lake (*TCalt*), included to avoid misspecification bias, also resulted in statistically significant estimates with the theoretically expected signs in the majority of angling areas analysed. The positive sign of this coefficient implies that an increase in the travel cost to reach a lake site results in an increase in the fishing trips on the Ticino River. This confirms the hypothesis that angling at a lake is a substitute to angling on a river.

The variable characterising the Hypothetical Travel Cost Model is the dummy variable *DHS*, the demand-shifter for a quality improvement. This variable distinguishes between the revealed trips given the current quality and the stated trips with a hypothetical low flow enhancement and is significantly different from zero at the 1% level for all the angling areas under consideration. This result indicates that there is a structural change in recreation demand once the environmental quality is improved, i.e. a quality improvement will lead to an increase in the number of trips, holding all other variables constant. The magnitude of this change depends on the numerical coefficient estimate and is reflected in the change in predicted trips (see Table 23 in section 5.4.4). While the coefficient estimates from the linear specification indicate that the

[55] The *F*-test tests a null hypothesis that all of the estimated slope coefficients are no different from zero. Large values of the *F*-statistic imply that at least one of the independent variables has an effect on the dependent variable.

highest impact of the quality change on the trips occurs for the Ticino River, in the semi-log specification it occurs in the Leventina&Blenio area.

The characterising variable of the Heckman sample selection model is *lambda*. This variable has been introduced in the frequency equation in order to prevent the selection criterion (group of anglers who fish on the Ticino River) from having a systematic impact on the estimated demand coefficients. In fact, the selected sample as a group will have a disproportionate number of people with high "energy", where "energy" stands for an unobservable element determining if people are in the group or not. If the unobservable energy also has an impact on the number of trips, the error terms of the choice decision and the frequency decision will be correlated, given that the unobservable energy is included in both error terms. Using observations on the group only to estimate the trip function will hence create biased estimators of the trip function relevant to the whole angling population. The inclusion of *lambda* in the model is supposed to free the frequency decision's error term from the part, which is correlated to the error of the choice decision. If the errors were uncorrelated, the frequency decision could have simply been estimated by *OLS* ignoring the selection equation (unless one is interested in it).[56] *Lambda's* coefficient has the expected negative sign throughout the models, given that censoring occurred from below (Greene, 2000). It is statistically different from zero in the semi-log functional form, but only for the whole Ticino River (A) in the linear specification. These results confirm the importance of applying the Heckman model where samples contain a substantial amount of zeros for the dependent variable.

As expected, income was not a consistently significant determinant of the site's recreation demands. This is a frequent result in recreation demand studies and is an indicator for the confidence we can have in marshallian CS, which is said (Willig, 1976) to be a good approximation for the hicksian demand when income effects are small. Interestingly enough, however, most of the income dummies have statistically significant coefficient estimates in the probit model. In fact, for the angling areas (B) and (C), they turn out to be statistically significant at a 1-% level. This might suggest that income levels are more likely to be a determining factor in the choice of the angling site than in affecting the number of recreational trips.

The dummy variable *Dpensioner* aims to capture the impact of being a pensioner on the frequency decision. The negative coefficient estimate, although not always statistically significant, indicates a minor tendency of pensioners compared to non-pensioners to undertake angling trips on the Ticino River.

The coefficient estimate of the dummy variable *Dperiod* confirms the hypothesis that anglers who normally angle only on week-ends take a lower number of trips than those who fish regularly throughout the week, although not consistently throughout the regions analysed. This might, however, be a problem of sample size, which is reduced by restricting the angling areas, making it unlikely to obtain statistically significant results.

Dgroup is a dummy variable that accounts for the impact of sharing a car for travelling to the recreational site on the individual number of angling trips. The coefficient of this variable is

[56] Note that, since *lambda* is an estimate and the error term in the frequency equation is heteroskedastic (Verbeek, 2000), the standard errors are incorrect, even though β is unbiased (see Heckman, 1979). Therefore, the standard errors have to be adjusted in order to correctly judge the significance of coefficients (Maddala, 1983). Fortunately, Limdep automatically adjusts the routinely computed second stage OLS standard errors (see Limdep, User's Manual, p. 714, note). For the theoretical procedure, see Heckman (1979).

significant in both model specifications only for the whole Ticino River. The negative sign was expected, indicating that travelling in groups imposes opportunity costs in terms of restrictions of individual freedom. The interesting thing is that in the first step probit model, this dummy produced statistically significant results. Its positive sign indicates the positive impact of travelling in groups on the probability of taking angling trips to the Ticino River. Moreover, this highlights an advantage of the Heckman model over the Tobit: the fact that it allows the same variable to have opposite impacts on choice and frequency decisions.

From a statistical point of view, the two-step Heckman model is a second-best alternative to maximum likelihood, since its *OLS* estimator is consistent but inefficient. The problem is that likelihood functions are difficult to derive when individual characteristics determine whether an individual is in the sample or not, i.e. when the threshold varies from person to person and is stochastic (Kennedy, 1998).

A comparison of the different estimation results will be presented in terms of Consumer Surplus results in section 5.4.4.

5.4.3 Efficiency and identification gains illustrated

The usefulness of the combination of data sources can be evaluated by inspecting the estimated coefficients of the separate revealed and stated models (Ben-Akiva & Morikawa, 1990). Two important potentials are the improved statistical efficiency of the estimation results and the possibility of identifying hypothetical preferences. Table 21 illustrates possible identification and efficiency gains presenting parameter results for the recreational demand on the Ticino River. The first column in Table 21 reports results based on the revealed data only. This corresponds to the traditional Travel Cost Model. In the second column the demand function is estimated with the stated data only. The third column reports the estimation results when revealed and stated preference data are combined.

The *identification gain* relies in the possibility of estimating preferences that were not identifiable from revealed preference data alone. This might occur for several reasons, as already specified before: the definition of a quality variable depicting low flows in single sites might not be possible. This prevents retrieval of any information on the value of a quality improvement by pooling trip data on sites with different flow levels in a multi-site model. A second reason could be the hypothetical nature of a quality improvement, that is, a quality improvement that is not actually in place. Augmenting actual behavioural data with stated data representing recreation behaviour given a low flow enhancement, the shift in demand due to the quality improvement can simply be modelled by introducing a dummy variable differentiating between actual trips and stated trips. This dummy variable is supposed to capture the effect of the quality improvement on the trip demand. The statistical significance of the shift can easily be tested with a *t*-test on this dummy. Table 21 shows a statistically significant positive parameter on the dummy variable *DHS*, indicating that a low flow enhancement will substantially increase recreation demand.

A further advantage of this approach is that a non-marginal quality change is valued. In fact, the parameter of the dummy variable reveals important information regarding the non-marginal quality change presented in the survey soliciting contingent behaviour. This might, depending on the context, be of greater policy relevance than the valuation of marginal quality changes.

Table 21 – Comparison of parameter estimates, semi-log Heckman, Ticino River (second step only) (*t*-statistics in brackets)

Coefficients	Revealed Data	Stated Data	Combined Data
Intercept	3.26***	3.45***	3.16***
	(10.660)	(12.039)	(14.772)
TC	-0.009***	-0.006*	-0.008***
	(-2.770)	(-1.881)	(-3.296)
Tcalt	0.01**	0.02***	0.013***
	(2.248)	(3.135)	(3.787)
DHS	-	-	0.39***
			(4.761)
DY1	0.29	0.31	0.30
	(0.883)	(0.975)	(1.300)
DY2	0.16	0.17	0.17
	(0.693)	(0.802)	(1.045)
DY3	-0.02	-0.15	-0.06
	(-0.092)	(-0.632)	(-0.379)
Dpensioner	-0.28*	-0.30*	-0.29***
	(-1.724)	(-1.941)	(-2.589)
Dperiod	-0.22	-0.23	-0.23**
	(-1.396)	(-1.603)	(-2.114)
Dgroup	-0.18	-0.22*	-0.20**
	(-1.362)	(-1.757)	(-2.188)
Lambda (λ)	-0.93***	-0.75***	-0.84***
	(-3.580)	(-3.072)	(-4.694)
Adjusted R^2	0.29	0.25	0.30
F-test	14.28***	12.09***	26.59***
	F(9,287)	F(9,287)	F(10, 583)

*, **, *** statistically different from zero at a confidence level of 90, 95 and 99%

The *efficiency gain* can be seen by looking at the statistical significance levels that appear to be generally higher in the combined model than in the separate revealed or stated models. For example *Dperiod*, the dummy variable which distinguishes between anglers who angle during the whole week and those who angle only during week-ends, did not appear to be statistically significant in the separate models, but became statistically significant in the combined model.

5.4.4 Consumer Surplus Estimates

Given the model specification (5.27), (5.28) and (5.29) and the econometric results of the marshallian demand functions presented in Table 19 and Table 20, using the formulas for truncated *CS* (5.23) and (5.24) it is possible to calculate the following welfare indicators:

- ***Individual seasonal consumer surplus for the actual situation (CS)[57]:*** This is an indicator of the monetary benefits accruing to recreational anglers frequenting the Ticino River during the 1998 angling season, and is represented in Figure 14 as the area below the demand curve without a quality improvement *x* between the mean travel cost to the choke price (maximum travel cost). Actual *CS* can be taken as a benchmark measure of the economic benefits generated by the recreational angling activity;
- ***Individual seasonal increase in CS due to a low flow enhancement (variation):*** The seasonal variation in *CS* indicates the average monetary value of an increase of low flows in the Ticino River accruing to recreational anglers in the 1998 angling season. The variation corresponds to the area *ABCD* in Figure 14, i.e. the difference between the *CS* when flows are at the hypothetical improved level and the *CS* when flow levels are at the original low level.

[57] No per trip-CS values have been computed, since, as Morey (1994) points out, assuming a constant utility of trips is a very restrictive assumption.

Figure 14 - Increase in Consumer Surplus due to a low flow enhancement

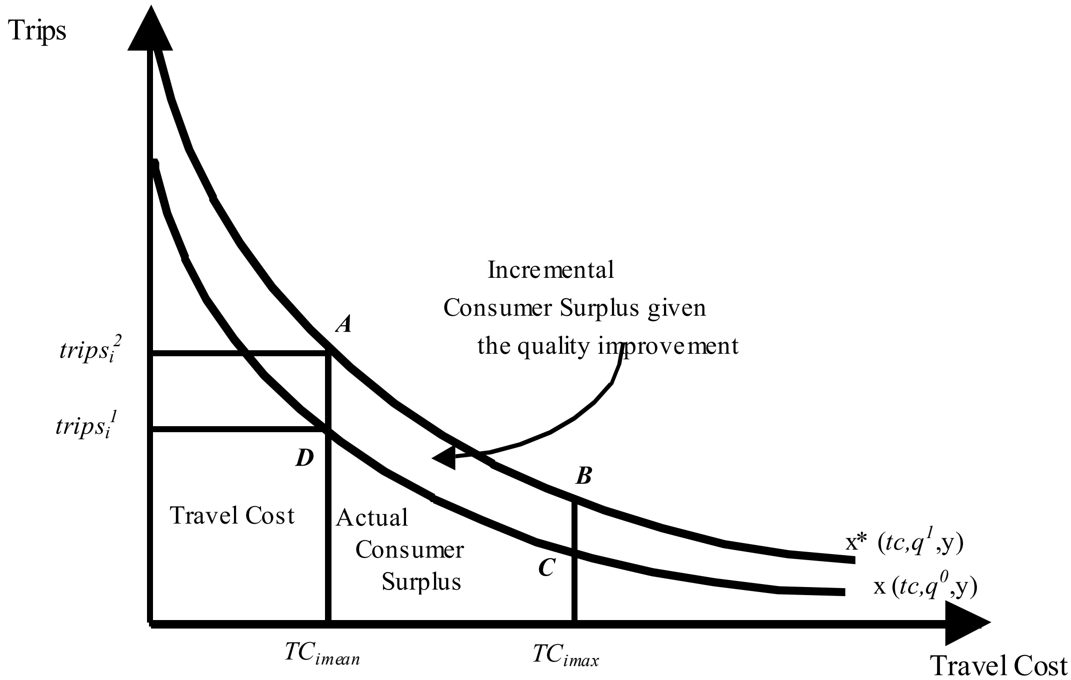

Table 22 illustrates these welfare indicators for the low flow enhancement in the Ticino River and the two sub-regions, the Leventina&Blenio and the Leventina area. The first column reports the truncated individual seasonal CS estimates for the actual situation. The second column instead presents the benefit estimates for the low flow enhancement, i.e. the CS-variation given the quality improvement. To obtain truncated measures, the highest travel cost observed in the sample is applied as the price that drives demand to zero (choke price). As suggested by Adamowicz et al. (1989), we truncated both linear and semi-log functional forms at the choke price. While the definition of a choke price is almost standard procedure in the semi-log functional form given its open tail, truncating the demand curve in the linear case as well could be important in reducing a bias inherent in the Hypothetical Travel Cost Model. In fact, the increase in *CS* due to a quality improvement is likely to be overestimated without choke price since the shift in the demand leads to an implicit choke price in the linear demand function which is very likely to lie beyond the range of values observed in the sample.

Given Hanley et al.'s (2003) statement that the relevant comparison in welfare terms is between predicted trips at the current water quality level and predicted trips at the improved level, the welfare indicators shown in Table 22 are computed using user's predicted trips for both the actual and the quality-improved situation. This guarantees that *CS* for both the actual and hypothetical situation will rely on a constant per trip price.

Table 22 – Truncated Actual Consumer Surplus and Variation of Surplus per season (in SFr.)[a,b,c]

		Actual CS	Variation of Surplus
A	**Ticino River** [d]		
	Linear	1'199	742
	Semi-log	839	439
B	**Leventina and Blenio**		
	Linear	542	477
	Semi-log	430	255
C	**Leventina**		
	Linear	552	389
	Semi-log	329	193

[a] A weighted mean of the *CS* is given for the areas where the dummy variable *Dperiod,* distinguishing between week-end anglers (group A) and anglers fishing during the week (group B), proved to be statistically significant. The mean was weighted by the population share of the two groups (20% group A and 80% group B as revealed by the sample and assumed to be representative)

[b] The numbers presented in the table are values for *CS* at net of fixed costs. The fixed costs consist of the fishing licence, the annual membership fee for the angling association and the annual expenditure for fishing equipment/gear. Since fixed costs are related to the angling activity on the whole territory and on either rivers, lakes and alpine lakes, only a part of them are relevant for the computation of net CS values for angling trips on the Ticino River. Based on several hypotheses[58], we estimate the fixed costs to be 70 SFr for group A and 90 SFr for group B leading to a weighted mean of 86 SFr. Note that, should these costs exceed the *CS* the individual receives from the recreational activity, some categories of anglers might be induced to give up their angling activity.

[c] The predicted number of trips has been used in the consumer surplus calculations. The independent variables are evaluated at their medians for these calculations.

[d] In contrast to Buchli et al. (2003), the *CS* values shown in Table 22 are at net of the costs for the fishing licence.

Table 22 reveals that the actual seasonal individual truncated *CS* for the Ticino River amounts to 839 SFr. for the semi-log functional and to 1'199 SFr. in the linear case. The truncated variation in *CS* determined by a low flow enhancement is quantified at 439 SFr. for the semi-log and 742 SFr. for the linear functional form per season and per angler. Considering the semi-log results only, this means that an average visitor would eventually pay 439 SFr. more than his or her current costs. Note that this does not mean that the cantonal authorities could charge each visitor 439 SFr. more since it represents an average net benefit, i.e. half the visitors would pay more and half would pay less (Loomis & Walsh, 1997). The half that would pay less would no longer visit if the fishing licence were increased by an amount of 439 SFr.

Restricting the area under analysis, Table 22 reveals that the actual truncated CS for the Leventina amounts to 329 SFr. when the semi-log functional form is applied and to 552 SFr. for

[58] Components of fixed costs for recreational anglers in Ticino:

	Group A	Group B
Licence	200 SFr	200 SFr
Annual angling association membership fee	50 SFr	50 SFr
Annual expenditure for equipment/gear	100 SFr	200 SFr
SUM	350 SFr	450 SFr

We formulated the following hypothesis for the computation of the part of the fixed costs which we want to attribute to the angling trips on the river Ticino and tributaries:
(1) the angling licence (including the membership fee for the angling association) and the angling equipment/gear can be used for angling trips either to rivers, lakes or alpine lakes. We assume that one third of the fixed costs can be attributed to angling in rivers (the remaining two thirds can be attributed to fishing in lakes and alpine lakes);
(2) the anglers of group A incur lower expenditures for equipment/gear than those of group B;
(3) 60% of the total angling trips are made on the Ticino River and its tributaries.

the linear functional form. The welfare increase due to a low flow alleviation (CS variation) varies between 193 and 389 SFr, depending on the functional form applied. The values are considerably lower than in those regarding the Ticino River. It is intuitive that as the area of analysis is restricted, both the actual CS and the variation in *CS* diminish. The reason is that what is valued here is recreational *use*-value; hence the seasonal use-value diminishes as overall use is diminished.

Results have been presented for either functional form used in the estimation of the recreational demand, given that from a statistical point of view there is no clear-cut indication. However, as mentioned by Garrod & Willis (1999), another important criterion for the choice of the functional form is how well the model predicts the actual outcomes. A comparison of the predicted with the actual trips could hence provide information on which to choose from the results generated by the two different functional forms.

Table 23 illustrates this comparison for the recreation trip data referring to the Ticino River. In the Heckman model, predictions can be produced for the trips of users, i.e. the trip value conditional on a positive number of trips, and for the population for which the sample is representative, i.e. the unconditional mean of the latent demand.

Since the scope of the study is the estimation of the value of a low flow enhancement for anglers who effectively take angling trips to the area under analysis, the expected trip value conditional on a positive number of trips is calculated, as presented in Table 23. Those who do not take any angling trips are supposed not to have any use value.

The prediction of the mean conditional on positive trips in the Heckman sample selection model is (Maddala, 1983; Bockstael et al., 1990):

$$E(q_i \mid q_i > 0) = \beta' x_i + \sigma \frac{\phi_i}{\Phi_i} \qquad (5.30)$$

where ϕ and Φ are the density function and the cumulative distribution function of the standard normal evaluated at $\beta' x_i / \sigma$ and σ is the standard deviation of the standard normal.

Table 23 – Revealed and predicted trips

		Revealed trips				Predicted trips		
		Actual situation	Hypothetical situation	Increase		Actual situation	Hypothetical situation	Increase
A	**Ticino River**							
	Mean	26	36	10	Linear	25	36	11
	Median	16	24	8	Semi-log	16	24	8
B	**Leventina and Blenio**							
	Mean	21	29	8	Linear	21	29	8
	Median	12	20	8	Semi-log	12	18	6
C	**Leventina**							
	Mean	18	26	8	Linear	19	27	8
	Median	10	15	5	Semi-log	10	15	5

Table 23 shows that for our data, there is a striking correspondence between the predicted trips estimated with the linear function form and the mean of actual trips, while the predicted trips from the semi-log form reflect the median number of actual recreation trips. Hence, for our data and based only on this comparison, the semi-log (linear) functional form seems to be indicated if the researcher reckons that the median (mean) number of trips better represents individual behaviour.

Overall, the results presented reflect the consistent benefits deriving from of a low flow alleviation in the Ticino River and hence emphasise the importance of policy action.

Chapter 6: Conclusions

The literature on economic valuation techniques applied to environmental amenities has proliferated in the last years, mainly in response to the growing awareness of the need for policy action to protect the environment and improve its quality. Given that protection measures are costly and that policy-makers normally face tight budget constraints, economic valuation plays an important role in environmental decision-making. The growing demand for valuation studies is an encouraging sign that understanding and consensus regarding the role of valuation in environmental decision-making is increasing.

The goal of this study has been to apply the Hypothetical Travel Cost Model (*HTCM*), a relatively new and promising direction in non-market valuation technique to the valuation of a hypothetical low flow alleviation in the Ticino River. The Ticino River, one of the main rivers in the Swiss Canton of Ticino, is adversely affected by low water flows and artificial flow alterations, mainly due to hydropower plants that abstract, divert and dam up water. This major negative externality of hydropower production particularly affects recreational anglers, who complain of the absence of fish due to the lack of water. Hence, they would presumably benefit substantially from a restoration of the rivers to their natural status or at least to an environmentally acceptable flow regime.

The Swiss Federal Water Protection Law (*WPL*) requires the cantonal authorities to take action if a careful and detailed valuation of costs and benefits accruing to all interested parties justifies it. Considering use values only, the potential gainers from a flow enhancement are recreational users, such as anglers, tourists, and the indigenous population. Hydropower plants, on the other hand, are likely to lose out because obliged to retain less water for energy production in order to restore flow levels. This burdens them with costs in terms of decreasing revenues. Moreover, opportunity costs of producing energy with alternatives to hydropower may be important. Replacing the lost electricity by fossil fuel-based energy implies increased emissions of air pollutants with costs in terms of damages to human health, and the natural and man-made environment. Hence, the estimation of the recreational benefits anglers derive from a low flow improvement constitutes an important element in an overall assessment whether from society's point of view the benefits generated by increasing flows outweigh the costs.

The Hypothetical Travel Cost Method (*HTCM*) used for this task is a hybrid between the Contingent Valuation Method and the Travel Cost approach. The fundamental idea is to make people report their behaviour under real circumstances and elicit their contingent behaviour given a constructed hypothetical scenario concerning a low flow alleviation. This allows for an econometric estimate of the increase in the demand for recreational angling trips and enables us to calculate the Consumer Surplus as an indicator of the welfare change given the quality improvement. The empirical results confirm consistent recreational benefits deriving from a low flow enhancement in the Ticino River.

The *HTCM* represents an important methodological improvement to the existing valuation approaches. It views the Contingent Valuation *(CVM)* and the Travel Cost Model (*TCM)* as complements rather than competing techniques and thus circumvents some problems the single approaches face. With the *TCM*, the valuation of quality improvements is not straightforward at all. In order to value characteristics such as changes in water quality, one needs to estimate the recreation demand as a function of these characteristics. This necessitates observing variation in water quality over recreational sites and pooling data to estimate multi-site models. In our case water flows are measured in a few points only. Hence, the application of the multi-site approach was not possible since the quality variable was not defined for all sites.

For these reasons, in past valuation exercises of quality, changes predominantly took place in the context of the Contingent Valuation Approach. However, strategic and protest behaviour, an approach-specific issue which has been present in this analysis, can seriously threaten the validity and reliability of *CVM* results. In fact, even if it is assumed that people are able to value a hypothetical situation in an unbiased manner (which has been questioned), the fact still remains that it has proven difficult to ensure truthful preference revelation. Individuals might in fact be induced to strategic or to protest bidding. The latter was encountered in this thesis, probably because although they feel to have a right for naturally flowing rivers the Contingent Valuation question implied that anglers did not have property rights.

Hence, the appeal of the *HTCM* with respect to the Contingent Valuation is that it enables us to value a quality improvement within a behavioural framework thereby possibly reducing the problem of untruthful responses. In fact, here anglers are not asked about their willingness to pay but rather about their contingent behaviour. An important advantage of the *HTCM* over the classical *TCM* is that a quality change can be valued without introducing a variable for the quality characteristic of interest in the model. This makes the analysis of quality changes at single sites possible. Moreover, with the *HTCM* it is possible to identify preferences for a quality improvement, which lies beyond observable data. This has been important for the valuation of a low flow alleviation in the Canton of Ticino given the hypothetical nature of the policy of interest.

However, in general, demand and benefit estimates depend on specific circumstances and researchers' judgement. The specification of the regression equation, the nature of the sample data, or the way research questions are posed can greatly affect the results. Judgement about these issues must be made case by case, as the literature on the valuation of environmental amenities is often not clear about best practice. In particular, the functional form specifying the recreation demand function has a determining role with considerable impact on final welfare measures. Unfortunately, theory provides no guidance on the functional relationship between the explanatory variables and the dependent variable depicting recreation behaviour. Other criteria have thus to be applied to make a choice. In the relevant valuation literature, two of the predominantly used relationships are the linear and the semi-log functional form. The linear functional form resulted in always higher welfare measures, both for the actual situation and the flow enhancement. However, given that from a statistical point of view no functional form was unambiguously preferable over the other, results for both functional forms have been presented in this thesis.

Two other issues having impacts on the welfare measures are the introduction of a choke price and the choice between actual and predicted trips in the computation of the Consumer Surplus. While the definition of a choke price, i.e. the travel cost which drives recreation demand to zero, has been common fare for the semi-log functional form given its open tail, this is not normally done in the linear case given that the choke price is defined by the model. In our case, the use of a choke price for the linear functional form relies on the recognition that the choke price implicit in the linear model proves to be much higher than the highest observed individual travel costs. Hence, the truncation strategy can reduce overestimation for both functional forms. This seems particularly important for the *HTCM*, where the rightward shift of demand for the improved situation implies an even higher choke price than for the current situation.

The choice between actual and predicted trips is basically dictated by the source of the stochastic error term. If it is believed that most of the error stems from omitted variables, the use of actual trips is indicated in the computation of the welfare measures. In the case however where the error term reflects measurement error in the dependent variable (recreation trips data), predictions of the number of trips might generate more reliable results. The calculation of the Consumer Surplus of a low flow alleviation in the Ticino River is obtained from the comparison of the *CS* in the current flow situation and the *CS* given an enhancement. The source of error is probably not the same: anglers are obliged to keep track of their catches, hence for the current situation actual trips are likely to be reliable. For the enhanced situation, hypothetical trip behaviour might be biased because of the hypotheticity of the situation, suggesting the use of predicted trips. In order to keep average travel costs constant for the calculation of the *CS* of an improvement, predicted trips have been applied to the current as well as to the hypothetical situation.

For Switzerland, this thesis seems to be the first study estimating the monetary benefits accruing to recreational anglers from a low flow alleviation in the Ticino River. It hence fills an information gap, which is important for policy-decisions. Furthermore, it is the first valuation study, which applies the combined *HTCM* approach to the valuation of environmental quality. In trying to comprehensively address concerns about low flows in the Ticino River from a socio-economic point of view, this thesis comes up with two main indicators:

(1) a benchmark measure of the *benefits accruing to recreational anglers in the current situation*, and

(2) the prediction *of the change in welfare* accruing to recreational anglers had a *low flow alleviation* taken place.

The results of the thesis confirm the recreational value of the Ticino River to anglers (between 839 and 1'199 SFr. per angler and year) and the potential for generating additional recreational benefits to the angling community by restoring the flow levels of the Ticino River (between 439 and 742 SFr. per angler and year). This information provides an important piece in the puzzle of the many interests in the water of the Ticino River. Knowledge of benefits can stimulate awareness of the significance of the environment and are fundamental to Cost-Benefit-Analyses (*CBA*). By explicitly considering all costs and benefits, valuation can increase transparency of policy decisions and options of action can be ordered in terms of efficiency. Overall, the *HTCM* has proven to be a viable method in the estimation of benefits accruing from an environmental quality improvement.

Appendices

Appendix 1 - Photographic illustration of a low flow enhancement

Appendix 2 - Characteristics of the sample

Variable		Description	Means, % of observations
Total number of respondents			381
Age			42.1
Trips			31.6
Income			
	DY1	=1 if the annual income lies within the range of 0-25,000 SFr.	5.8%
	DY2	=1 if the annual income lies within the range of 25,000-75,000 SFr.	58.8%
	DY3	=1 if the annual income lies within the range of 75,000-125,000 SFr.	27.6%
	DY4	=1 if the annual income is higher than 125,000 SFr.	7.8%
Dperiod		=1 if fishing only during weekends	20.2%
Dpensioner		=1 if pensioner	15.2%
Dpond		=1 if fished in sports fishing (stocked) ponds	
Dcar		=1 if in possession of at least one car	52.5%
Dsatisfaction		=1 if not satisfied about actual situation	90.3%
Dsottoceneri		=1 if originally from the "Sottoceneri" (southern region of the Canton of Ticino)	46.2%
Deducation		=1 for higher education	30.7%

Appendix 3 - WTP payment card data: Interval Selection Frequencies (N=381)

SFR Interval	Frequency	%
0	205	53.8
0 - 10	20	5.3
10 - 20	34	8.9
20 - 30	15	3.9
30 - 40	16	4.2
40 – 50	31	8.1
50 – 60	6	1.6
60 – 70	0	0
70 – 80	2	0.5
80 – 90	0	0
90 - 100	37	9.7
100 – 110	0	0
110 – 120	4	1.1
120 – 130	0	0
130 – 140	0	0
140 – 150	4	1.1
150 – 160	0	0
160 – 170	0	0
170 – 180	3	0.8
180 – 190	0	0
190 +	4	1.1

Appendix 4 - Questionnaire

Questionario sul
VALORE DEI FIUMI TICINESI PER I PESCATORI

Parte 1: Domande riguardanti le sue abitudini nella pratica della pesca

In questa parte del questionario vorremmo rivolgerle alcune domande riguardanti le sue abitudini nella pratica della pesca e la sua valutazione della situazione attuale del livello dei deflussi minimi dei fiumi ticinesi.

1. **Dove si reca normalmente a pescare?** (apporre una o più crocette)

Pesco nei **fiumi** □(1)
Pesco nei **laghetti alpini** □(2)
Pesco nei **laghi** □(3)

Se <u>non</u> pesca nei fiumi, continui con la domanda 13.

2. **Nella stagione di pesca 1998, in media quante volte si è recato a pescare nei fiumi del cantone Ticino?**

ogni giorno	□(1)	2 volte al mese	□(4)
3-4 volte la settimana	□(2)	1 volta al mese	□(5)
1-2 volte la settimana	□(3)	3-4 volte all'anno	□(6)
altro	□(7)		

3. **Quando va a pescare, quanto tempo dedica in media a questa attività?**

ore approssimative:____________

4. **Normalmente in che giorni della settimana va a pescare?**

nei giorni feriali □(1)
nei giorni festivi □(2)
sia nei giorni feriali che festivi □(3)

5.

a) Frequenta in modo regolare dei laghetti privati per la pesca sportiva?

sì □(1) no □(2)

b) Trascorre regolarmente delle vacanze all'estero dedicate alla pesca?

sì □(1) no □(2)

6. **Lei fa parte di un'associazione naturalistica (escluse le associazioni di pesca)?**

sì □(1) no □(2)

7. Quale tipo di pesca pratica nel fiume? (apporre una o più crocette)

□(1) Pratico la pesca a mosca

□(2) Pratico la pesca al tocco/con esche naturali

□(3) Pratico la pesca a "Spinning" con esche artificiali

□(4) Altro:

8. È' abbonato ad una rivista specializzata di pesca (escluso il bollettino sociale della FTAP)?

sì □(1) Titolo: ____________________

no □(2)

9. È soddisfatto del livello attuale dei deflussi minimi dei fiumi ticinesi?

□(1) molto soddisfatto □(2) soddisfatto
□(3) poco soddisfatto □(4) completamente insoddisfatto
□(5) indifferente alla problematica dei deflussi minimi

10. Normalmente da dove parte per andare a pescare?

Luogo (comune) di partenza: ____________________

11.

a) Potrebbe completare la seguente tabella con riferimento ai tre luoghi di pesca da lei maggiormente frequentati, indicando:

- **un comune nelle vicinanze del tratto di fiume dove pesca,**
- **le rispettive zone di pesca (vedi carta dei settori allegata),**
- **la distanza approssimativa (in km) dal luogo di partenza al luogo di pesca,**
- **quante volte si è recato a pescare in questi tre luoghi nella stagione di pesca 1998 (i luoghi possono anche trovarsi nella stessa zona),**
- **quale mezzo di trasporto utilizza normalmente per recarsi a pescare.**

	comune vicino al tratto di fiume	Zona di pesca (codice)	Km percorsi (solo andata)	Numero di uscite (stagione di pesca 1998)	Mezzo di trasporto (automobile, mezzi pubblici bicicletta/motorino, a piedi)
1)					
2)					
3)					

b) Se utilizza l'automobile, quanti pescatori viaggiano normalmente con lei?

Numero di persone (escluso lei): ____________________

12. In mancanza della possibilità di poter pescare nei fiumi ticinesi (p. es. carenza d'acqua dovuta a siccità), quali di queste alternative sceglierebbe? (apporre una o più crocette)

		Può indicare dove (comune più vicino o zona di pesca)?
Pescare nei laghi	□(1)	______
Pescare nei laghetti alpini	□(2)	______
Pesca sportiva	□(3)	______
Pescare nei fiumi di altre regioni svizzere o estere	□(4)	______
Svolgere un'altra attività all'aperto	□(5)	______
Nessuna di queste alternative	□(6)	______
Altro:	□(7)	______

Parte 2: Valutazione del cambiamento del livello dei deflussi minimi

I pescatori sostengono da molto tempo la necessità di **aumentare il livello dei deflussi minimi** nei fiumi ticinesi in modo da **migliorare le condizioni di pesca**. A titolo di esempio le fotografie allegate mostrano un possibile cambiamento del livello dei deflussi.

13. Supponiamo ora, in via del tutto ipotetica, che il livello dei deflussi minimi dei fiumi ticinesi venga aumentato determinando un **miglioramento apprezzabile della pescosità** (un aumento della pescosità di ca. 250 trote di misura per chilometro di fiume).

Dato questo aumento ipotetico del livello dei deflussi e quindi della pescosità, potrebbe indicare di quanto modificherebbe il numero delle sue gite ai tre luoghi di pesca da lei indicati nella domanda 11a?

	comune vicino al tratto di fiume	Zona di pesca (codice)	numero complessivo di uscite in una stagione di pesca con l'aumento dei deflussi
1	______	______	______
2	______	______	______
3	______	______	______

14.

a) L'aumento del livello dei deflussi minimi migliora le condizioni di pesca ma comporta delle perdite in termini di quantità di energia elettrica prodotta.

Potrebbe indicare quanto sarebbe disposto a contribuire annualmente per un aumento dei deflussi minimi?

0 Frs.	□	10 Frs.	□
20 Frs.	□	30 Frs.	□
40 Frs.	□	50 Frs.	□
60 Frs.	□	70 Frs.	□
80 Frs.	□	90 Frs.	□
100 Frs.	□	110 Frs.	□
120 Frs.	□	130 Frs.	□
140 Frs.	□	150 Frs.	□
160 Frs.	□	170 Frs.	□
180 Frs.	□	190 Frs.	□

cifra superiore: ______________________

b) Se la risposta al punto a) è 0 Frs., potrebbe indicare il motivo?

□(1) Non sono interessato ad un aumento dei deflussi minimi.

□(2) Non lo so

□(3) Altro: ______________________

____

____

____

Parte 3: Informazioni socio-economiche

Per una corretta valutazione economica dei fiumi ticinesi è importante conoscere alcuni dati socio-economici delle persone intervistate. **Vi ricordiamo che queste informazioni verranno utilizzate in modo assolutamente anonimo**.

15. Qual è il suo anno di nascita: 19 ________

16. Sesso:

femminile □(1)

maschile □(2)

17. Qual è il suo luogo di domicilio?

comune politico: ______________________

codice postale: ______________________

18. Qual è il grado di formazione da lei raggiunto?

Scuola obbligatoria □(1)
Formazione professionale (p.es. apprendistato) □(2)
Maturità/Diploma □(3)
Università e Politecnici □(4)
Altre formazioni: □(5) ____________________

19. Qual è la sua attività professionale?

a) Settore occupazionale:		b) Posizione professionale:	
Agricoltura	□(1)	Lavoratore autonomo	□(1)
Industria	□(2)	Dipendente	□(2)
Artigianato	□(3)	Libero professionista	□(3)
Commercio	□(4)	Imprenditore	□(4)
Servizi	□(5)	Studente	□(5)
Pubblico impiego	□(6)	Pensionato	□(6)
non attivo	□(7)		

c) Lavora a tempo pieno? sì □(1) no □(2)

20.
a) Quante persone vivono nella sua economia domestica?

b) Di queste quante sono attive professionalmente?

c) Quante hanno meno di 18 anni?

____

21. Potrebbe indicare in modo approssimativo il reddito annuale lordo dell'intera economia domestica?

□(1)	0-25'000 Frs.	□(4)	76'000-100'000 Frs.
□(2)	26'000-50'000 Frs.	□(5)	101'000-125'000 Frs.
□(3)	51'000-75'000 Frs.	□(6)	oltre

22. Quante automobili possiede la sua economia domestica?

____

Ringraziamo per la cortese e preziosa collaborazione!

Appendix 5 - Angling map

Source: Ufficio Caccia e Pesca, Dipartimento del Territorio del Canton Ticino

Appendix 6 - Angling zones

TICINO RIVER				
	Three Valleys			**Bellinzona area**
	Leventina	Blenio	Riviera	
Angling zones	BE L1 L2	B1 B2	BD	BZ
% of trips	0.35	0.05	0.26	0.34

	Sopraceneri			Sottoceneri	
	Ticino River		Locarno area/ Vallemaggia	Lugano area	Mendrisio area
	Three Valleys	Bellinzona area			
Map of angling zones	BE L1 L2 B1 B2 BD	BZ	BA CV LA M1 M2 ON RO VZ GB	CA MT VD	MA ME

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