Estimating the benefits of low flow alleviation in rivers: the case of the Ticino River

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In Switzerland 60% of electricity is produced by hydropower plants. The construction and operation of these plants determine some negative environmental externalities, such as diminishing groundwater levels and spring flows, and a reduction in river flow, which can severely curtail recreational and fishing activities. This study concentrates on an ex-ante appraisal of the monetary benefits resulting from an enhancement of river flow for recreational fishing purposes. A comparison of estimates of these benefits to the corresponding costs, in terms of loss of electricity production, incurred by hydropower plants to alleviate low flows may be useful for policy makers. For this analysis, as suggested by Layman *et al.* (*Land Economics* **72**, pp. 113–28, 1996), the Travel Cost Method (TCM) is extended to estimate the economic value of recreational fishing in the Ticino River (the most important river of the Canton Ticino) under existing and hypothetical river flow conditions. Anglers were asked to state how the number of trips they took to the Ticino River would change if an increase in the river flow was imposed on the hydropower plants. The empirical results show that an enhancement of river flow increases the annual consumer surplus for a typical angler by approximately 440 SFr.

INTRODUCTION

In Switzerland 60% of electricity is produced by hydropower plants. The construction and operation of these plants determines some negative environmental externalities, such as diminishing groundwater levels and spring flows, and a reduction in river flow, which can severely curtail recreational and fishing activities. This problem is more marked in mountain rivers, because the majority of hydropower plants are located in the alpine regions. To alleviate this situation, in 1991 the Swiss Government passed a new law which requires the cantonal administration to improve the quality of the rivers. One of the most important measures in this regard is the increase in the flow levels.

In the Canton Ticino, an alpine region located in the Italian part of Switzerland, there are two main rivers, the Ticino and the Maggia, adversely affected by low flows caused by diverting water to hydropower plants. Obviously, low flow alleviation involves an increase in costs for hydropower plants in terms of lost production, because part of the water cannot be exploited for energy production. This increase in production costs could compromise the competitiveness of the Swiss hydropower sector. Thus, the problem becomes one of assessing whether from society's point of view the benefits generated by increasing flows outweigh the costs.

Since there are several important recreational activities associated with free-flowing rivers, such as canoeing, boating, fishing, hiking, and others, a large part of the popula-

tion of Ticino would probably benefit from an enhancement of the actual situation of the Ticino and Maggia Rivers. In particular, hydropower plants and dams have an impact on the natural habitat of fish species. This constitutes the major reason for fishermen to insist on low flow alleviation; they complain the absence of fish is a consequence of the absence of water. The estimation of the recreational value of fishing could therefore provide a first indicator of the importance of free-flowing rivers.

The aim of this paper is to perform an ex-ante appraisal of the monetary benefits resulting from an enhancement of river flow for recreational fishing purposes. Therefore, the results of this study could be employed in cost-benefit analysis.

This article is organized as follows. Section II presents the travel cost model for the estimation of the recreational value of fishing. Section III presents the data for 413 anglers who participated in the investigation. The empirical results are discussed in Section IV. The benefits of a hypothetical increase of river flow for fishing purposes are examined in Section V, and the conclusions are presented in Section VI.

II. HYPOTHETICAL TRAVEL COST METHOD

In the last twenty years the scientific world has produced a substantial number of studies estimating the economic value of quality improvements of environmental goods. Many of these studies applied the Contingent Valuation Method, while others employed the Travel Cost Method with the inclusion in the model of site quality characteristics variables, the Hedonic Travel Cost Method or the Hypothetical Travel Cost Method.[1]

In the case of an improvement in river quality, Garrod and Willis (1996) estimated the benefits of low flow enhancement for the River Darent using the Contingent Valuation Model (CVM). In their study the respondents to the questionnaire (the households in the region of the River Darent) were asked to estimate their willingness to pay for various improvements in flow levels. At the beginning of the study the possibility of also applying the contingent valuation method was taken into serious consideration. However, after a discussion with some officers of the main anglers' associations, it was discovered that anglers in Ticino consider an increase in flow level their right. Therefore, the results obtained by a CVM study would be biased because of strategic behaviour, i.e.

respondents would not reveal their effective Willingness To Pay (WTP) for a quality improvement in spite of an evident strong interest in the enhancement of low flow. For this reason it was decided to overcome this problem using the Hypothetical Travel Cost Model (HTCM) proposed by Layman et al. (1996).

The HTCM is based on the traditional Travel Cost Method (TCM). The basic idea of the TCM is that the number of trips to the recreational site, in this case a river, will decrease with increases in distance travelled. The demand for a recreational site depends on the price of consuming recreation, which in the TCM varies directly with the distance of the consumer from the site. In the TCM the price is made up of the variable out-of-pocket costs for the trip and the opportunity cost of travel time. Once information on the travel costs and trips taken during one year to a recreational site is obtained from visitors, a demand curve can be estimated from which to calculate consumer surplus.

The HTCM consists of constructing a hypothetical scenario concerning an improvement of the quality of the site, in this case a low flow alleviation scenario, and then asking respondents how many trips they would make under actual and hypothetical circumstances. Using the information from visitors on the travel costs and trips taken during one year to a recreational site under current and hypothetical conditions, two demand curves can be estimated. Moreover, as suggested by Layman et al. (1996), travel cost is an unbiased measure of the price variable for the hypothetical situation since it does not change with circumstances.

Model specification

The general form of the HTCM for the recreational fishing demand for the Ticino River is:

$$NV_{iT}^k = f(P_{iT}, PS_{il,}, Y_i, D_i, DHS_i) \qquad (1)$$

where NV_{iT}^k is the number of visits to the Ticino River by individual i under scenario k, P_{iT} is the implicit price or travel cost to the Ticino River by individual i, PS_{il} is the price faced by individual i for visits to substitute sites l, Y_i is individual i's income, and D_i is a vector of socio-economic variables of an individual. In order to test for the effects of the hypothetical low flow alleviation on the number of trips we introduce in the model a dummy variable DHS which is equal to 1 for observations related to the hypothetical situation and 0 for observations related to the actual situation. This dummy variable will allow the

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[1] For studies using the contingent valuation method see Garrod and Willis (1996), Green and Tunstall (1991), Desvousges et al. (1987); for studies using the travel cost method see Vaughan and Russel (1982), Smith and Desvousges (1985), Caulkins et al. (1986); for studies using the hedonic travel cost method see Brown and Mendelsohn (1983) and for an application of the hypothetical travel cost method see Layman et al. (1996).

actual and the hypothetical demand for trips to the Ticino River to be estimated.[2]

The choice of the functional form for the estimating equation is a matter of economic implications as well as econometric convenience. In the literature the linear and the semi-log specifications (e.g. Vaughan and Russel, 1982; Smith, 1988) are frequently applied.

The study utilized the semi-logarithmic functional form, with the HTCM model specification being:

$$\ln NV_{iT}^k = \alpha + \beta_P P_{iT} + \beta_{PSlake}PSlake_a + \beta_{DHS}DHS_i$$
$$+ \beta_{DY1}DY1_i + \beta_{DY2}DY2_i + \beta_{DY3}DY3_i$$
$$+ \beta_{Dperiod}Dperiod_i$$
$$+ \beta_{Dpensioner}Dpensioner_i + \beta_{Dgroup}Dgroup_i \qquad (2)$$

The dependent $\ln NV_{iT}^k$ is the log of the number of trips (actual or hypothetical) to the Ticino River by person i, where $k = 1$ for actual trips and $k = 2$ for trips under a hypothetical low flow alleviation. The costs for person i to travel to the Ticino River are P_{iT}. The travel costs to substitute site l on the nearest lake (Ceresio or Verbano) is $PSlake_{il}$. DHS is a dummy variable which is equal to 1 for observations related to the hypothetical situation and 0 for observations related to the actual situation. Moreover, the model introduced a set of dummy variables for household income categories, a dummy variable to distinguish anglers that go fishing mostly during the weekend from those going any day of the week, a dummy variable whether the respondent is pensioner, and a dummy variable for the respondents who travel to the fishing sites in groups or on their own.

III. DATA

The data was collected in a mail survey on recreational fishing patterns in the southern part of Switzerland in 1998. The questionnaire was sent to 2245 fishers who were registered as having bought a fishing licence for the 1997 season. Of the 644 persons who answered the survey, 231 observations had to be dropped from the sample because of either missing data or inconsistent or implausible answers. The sample used for the estimations is therefore composed of 413 observations on actual trips and 413 observations on hypothetical trips.

Tables 1 and 2 present some statistics of the variables used in the estimation of Model (2).

From each respondent of the survey two observations on the independent variable NV_{iT}^k were obtained: the actual number of trips and the number of trips they would have made under a hypothetical low flow alleviation.

Table 1. *Continuous variables used in the regression (statistics of users)*

Variable	Description	Mean	Standard deviation	1. quartile	3. quartile
NV_{iT}^1	Actual number of trips during one fishing season to the Ticino River	26	25.6	7	40
NV_{iT}^2	Hypothetical number of trips during one fishing season to the Ticino River	36	34.1	12	50
P	Travel cost to Ticino River (opportunity costs evaluated at 25% of hourly wage rate)	41.2	26.9	13.9	63.3
$PSlake$	Substitute price for recreational fishing in either Lake Ceresio or Lake Verbano	19.3	14.7	8.6	22.5

Table 2. *Qualitative (dummy) variables used in the regression*

Variable	Description	% of observations
DHS	= 1 if low flow improvement	50.0
DY_1	= 1 if the annual income lies within the range of 0–25 000 SFr.[a]	5.7
DY_2	= 1 if the annual income lies within the range of 25 000–75 000 SFr.	58.9
DY_3	= 1 if the annual income lies within the range of 75 000–125 000 SFr.	27.3
DY_4	= 1 if the annual income is higher than 125 000 SFr.	8.1
D_{period}	= 1 if fished only during weekends	19.2
$D_{pensioner}$	= 1 if pensioner	17.8
D_{group}	= 1 if travelling in group (of two anglers or more)	56.9

Note: [a] One Euro corresponds to around 1.5 SFr.

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[2] For the estimation of an HTCM it is necessary to get from each respondent of the survey two responses on the independent variable NV: the actual number of trips and the number of trips they would have made under a hypothetical low flow alleviation.

Information on the actual and hypothetical flow situation of the Ticino River was presented to the respondents using two pictures illustrating the effects of the increase in the low flow on the appearance of the river. The pictures were taken in a representative fishing point of the Ticino River. It is assumed that the number of visits per angler to the Ticino River increases or decreases depending on whether they expect the river flow improvement will have a beneficial or detrimental effect on the value they obtain from recreational fishing.

The construction of the travel cost variable (P_{iT}) to the Ticino River as well as the travel cost variable for alternative sites on the nearest lake (*PSlake*) follows Layman *et al.* (1996):

$$P_{iT} = \frac{(\text{Distance}_{iT})\,(\text{Costs per kilometre})}{\text{Group Size}_i}$$

$$+ (\%Wage)\left(\frac{\text{Income}_i}{2000}\right)(Time_{iT})$$

$$+ \text{Fishing bait per trip} \qquad (3)$$

The travel cost variable is composed of three parts: the transport costs, the opportunity costs of time and the costs for the fishing bait. Transport costs were defined as the number of kilometres travelled to the site multiplied by a per kilometre cost and divided by the number of persons travelling together.[3] The opportunity cost of time is an estimate of the cost of an individual's time while he or she is travelling to a fishing site. Unfortunately, there is little agreement about the most appropriate valuation of the opportunity cost of time. For this reason, several studies apply and compare different values.[4] In this study we evaluated the opportunity cost of time at 25% of the hourly wage rate.

IV. ESTIMATION RESULTS

Since the data set represents a large sample of anglers living in the Canton Ticino, a part of them records no sample visits to the Ticino River, because they chose to fish in other rivers. If only nonzero visit observations are used in parameter estimation, ordinary least squares procedures would yield inconsistent estimates from selectivity bias. Consequently, as suggested by Bockstael *et al.* (1990), the

Heckman two-step procedure is employed in this study to circumvent this problem. In a first stage a probit model is estimated to predict the probability of positive versus zero visits[5] and then a demand equation is estimated using OLS and with the addition in the explanatory variables of a truncation variable. As presented by Greene (1993), the truncation variable is calculated from the probit equation and is called the inverse Mills ratio. This ratio is introduced in the second equation in order to take into account the fact that the demand equation is estimated using a sample of anglers with positive visits.

The results of the estimation presented in Table 3 were obtained using the LIMDEP econometric package. The table reports the parameter estimates of the coefficients obtained in the second stage of the Heckman procedure. The statistical results of the probit analysis used in the first stage of estimation are available upon request.

The goodness-of-fit (R^2) measure is 0.30. The explanatory power of the regressions is reasonably good given the individual cross-section data. Many of the specified socio-

Table 3. *Estimation results (t values in parentheses)*

	Heckman 2. step (semi-log OLS)
Intercept	3.16**
	(14.772)
P	−0.01**
	(−3.296)
PSlake	0.01**
	(3.787)
DHS (Hypothetical Situation)	0.39**
	(4.71)
DY_1	0.30
	(1.300)
DY_2	0.17
	(1.045)
DY_3	−0.06
	(−0.379)
D_{period}	−0.23*
	(−2.114)
$D_{pensioner}$	−0.29**
	(−2.589)
D_{group}	−0.20*
	(−2.188)
Lambda	−0.84**
	(−4.694)
adjusted R^2	0.30

Notes: *, ** significantly different from zero at the 95 and 99% confidence level.

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[3] In this specific case, the group size in the computation of the travel cost variable (P_{iT}) is always set equal to one. This specification is due to the fact that we do not have accurate information on the variable 'group size' since the number of persons travelling together will presumably vary from trip to trip. It has to be considered that petrol costs are only about 15% of total costs per kilometre (see Touring Club Suisse). Therefore, our simplifying assumption shouldn't have a substantial impact on the overall travel costs.
[4] On this problem, see Layman *et al.* (1996) or Vaughan and Russel (1982).
[5] For the estimation of the first step (participation equation) the probit model was specified using the same economic variables of the demand function (2). Further, some additional dummies for the socio-economic characteristics of the respondents were introduced. The dependent variable is equal to one if the individual takes at least one angling trip to a site on the Ticino River and 0 else.

economic factors have statistically significant effects. However, the coefficient estimate of the variable Lamda (the inverse of the Mill's ratio) is statistically significant at the 1% level. Consequently, deleting the observations corresponding to zero visits would introduce sample selection bias. The coefficient on travel cost (P) has a negative sign and is significant at the 1% level. As expected by theory, the coefficient of the substitute price variable (*PSlake*) has a positive sign and is also significant at the 1% level. Therefore, even an important river like the Ticino is considered to have substitutes by users. The direction and the magnitude of the effect of a low flow enhancement on the number of visits can be seen from the coefficient of the DHS dummy variable. The coefficient on this variable has a positive sign and is significant at the 1% level. This implies that, *ceteris paribus*, the demand for fishing in the Ticino River would be significantly increased with low flow alleviation.

The impact of income on the number of visits was tested using three demand shifters. The coefficient estimates are not statistically significant. Therefore, income seems to have no influence on demand for trips. Finally, the dummies for the period, for being pensioner and for travelling in groups are all significant and show the same negative effect on the number of trips taken during a fishing season to the Ticino River.

V. ESTIMATED BENEFIT INCREASES FOR LOW FLOW ALLEVIATION

As stated earlier, the objective of the analysis of recreational behaviour has been to develop a model providing the basis for estimating the economic benefits for anglers associated with an improvement in river flow conditions of the Ticino River. As an indicator of the welfare increase due to a quality improvement the concept of consumer surplus was utilized, which represents a monetary measure of an individual's utility change. The frequently used Marshallian consumer surplus, employed in this study, is defined as the difference between the amount an individual would be willing to pay for a good with a constant per-unit price and with a given income, and the amount actually paid.

Figure 1 illustrates two demand curves. The first curve (D_1) represents the individual demand for the Ticino River under the current flow situation, while the second curve (D_2) shows the demand under a hypothetical low flow alleviation. Therefore, it is expected that an improvement in river quality shifts the demand curve to the right.
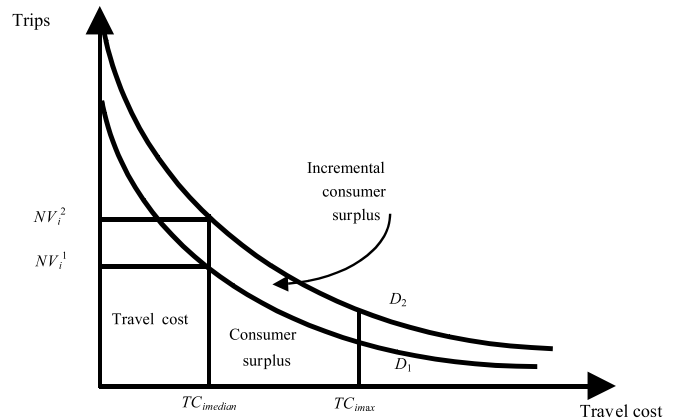

Fig. 1. *Change in consumer surplus for hypothetical trips*

The consumer surplus for a representative angler is presented in Fig. 1 as the area below the estimated demand curve (D_1) and above the travel cost corresponding to the average number of visits to the recreational site.

The area between the two individual demand curves is a measure of the benefits of low flow alleviation. The greater attractiveness of the site under improved circumstances relative to the site under original circumstances could result in an increase in recreational trips equal to $NV_i^2 - NV_i^1$. This increase could be in part a diversion of activity from other sites where, by assumption, quality has not changed, and in part an increase in aggregate recreation activity.

The Heckman estimation results presented in Table 3 can be used to calculate the change in the consumer surplus due to an enhancement of the flow level for a representative angler.[6]

For the calculation of the Consumer Surplus (CS) for the actual and hypothetical situation we follow Layman *et al.* (1996) integrating below the estimated demand function (2) from the median value of the travel cost in the sample up to an upper price determined on the basis of the travel cost in the sample, since the semilog specification of the demand function implies that there will be no price intercept, but only an asymptotic approach to the price axis. The increase in CS has therefore been calculated as

$$\Delta CS = \int_{pmedian}^{p\max} NV(DH=1) - \int_{pmedian}^{p\max} NV(DHS=0)$$

where $DHS = 1$ stands for the situation with improved low flows.

These estimates are illustrated in Table 4.

The consumer surplus (CS) is a monetary measure of the benefits of fishing and varies with different low flow conditions. It has been calculated for the actual as well as the hypothetical situation. As reported in Table 4, with an

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[6] Per season a representative angler takes 16 trips (median value) to the Ticino River and his annual income lies within the range of 25 000–75 000 SFr. Following Smith (1988) the median value is calculated of the trips to the Ticino River excluding the zero trip observation.

Table 4. *Consumer surplus estimates (in SFr.) based on the Heckman model*

	Actual Situation	Hypothetical Situation
Seasonal consumer surplus[a]	925	1364

Note: The CS values indicated here are weighted means of the CS estimated for two groups of anglers, distinguished by the dummy D_{period}: those who chose to go fishing mostly during the weekend and those going any day of the week.

improvement in flow conditions anglers increase their seasonal CS from 925 SFr to 1364 SFr, corresponding to an increase in the seasonal CS of approximately 440 SFr. These estimates are lower than the values found by other studies on this specific topic (see e.g. Layman *et al.*, 1996).

To be useful for policy purposes, the estimated benefits of an enhancement of the flow level must be aggregated across a relevant population of anglers. Within the current application, the total economic value of the improvement of the quality of the Ticino River would be estimated by multiplying the increase in the seasonal CS by 3000, which is the approximate number of anglers who fish in the Ticino River. Thus, following this approach the total economic value for the anglers would be approximately 1 317 000 SFr.

VI. CONCLUSION

This study concentrates on an ex-ante appraisal of the monetary benefits for recreational fishing purposes in the Ticino River resulting from an enhancement of river flow. Thus, the results of this study provide a first indicator of the benefits of free-flowing rivers for anglers.

For the purpose of this study the Hypothetical Travel Cost Method suggested by Layman *et al.* (1996) was utilized. This method seems to be more appropriate than the contingent valuation in situations where strategic behaviour could seriously affect the reliability of the results.

The empirical results show that an enhancement of river flow increases the annual consumer surplus for a typical angler by approximately 440 SFr. The total economic value of this improvement in the flow is approximately 1 317 000 SFr.

Of course, an enhancement of the flow involves costs, and then the problem for future research becomes one of assessing whether the benefits outweigh the costs, in term of lost production of hydropower plants.

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