Economic Valuation of Quality Improvement and Flow Regulation in the Doubs

Sandra Gogniat

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Abstract

This paper evaluates the benefit resulting from an improvement in water quality and flow regulation in the Doubs. The river's biodiversity is nowadays threatened by pollution and large flow variations caused by hydropower plants. A hypothetical travel cost method is used, to estimate the economic value of recreational fishing in the Doubs under the situation in 2010 and under a hypothetical improvement. The survey includes responses from 225 anglers about their behavior under the two situations. Since each angler reported the number of visits for up to 3 fishing sites, a correlated random effects model could be estimated, allowing to control for unobserved heterogeneity. By comparing consumer surplus estimations in the two situations, the annual benefit ranges from 1450 CHF to 1700 CHF per angler. Since recreational use is only a small part of the total economic value of the river, these estimations are not sufficient to give a complete measure of the economic benefits of the river's restoration. However, an ex ante appraisal of a part of these benefits is useful for policy makers for comparison with restoration's costs.

Keywords: Hypothetical travel cost method, recreational demand, environmental benefits evaluation, water quality, river flow, correlated random effects.

1. Introduction

The Doubs is a river of 453 kilometers, mainly located in France and builds the natural border at the northwest of Switzerland.

For a few decades now, biodiversity and biological quality of the Doubs have been threatened. Trout and grayling catches in the canton of Jura have fallen by 70% in 15 years (Fédération cantonale des pêcheurs jurassiens (2004)). Other species such as the apron or "le roi du Doubs", known to scientists for their scarcity, are also endangered. The situation is even more critical since January 2011, as many species have been dying in the Doubs because of a parasite[1].

The principal causes of the river's general degradation since 1970's have been studied carefully[2]. At that time, wastewater from La Chaux-de-Fonds, and French cities such as Pontarlier or Morteau was flowing in the Doubs without being treated. This wastewater contained toxic substances from industry, such as heavy metals, as well as household's waste. In addition, throughout this period, and the situation is even worse for several years now, hydropower plants such as the dam of the Châtelot have imposed rapid flow variations at electricity peak times. As a result, species have experienced undesirable variations in water levels, which has caused extensive damages everyday on fishes and benthic animals[3]. Finally, for the last ten years, the Doubs has contained, like other rivers, micro-pollutants resulting from human activity (e.g. medicines, birth control pills) or from agriculture and intensive forestry (pesticides, substances used to treat wood).

The situation is complex since none of these previous factors is able to explain by itself the degradation. Moreover, the river lies in a natural reserve of national importance (there exists a project of a regional natural park[4]) and international, on the border between France and Switzerland. Consequences are diverse, going from the dissatisfaction to see these species disappear to the threat of the entire ecosystem constituting the river's notoriety. But this could lead to more important effects, when we think about the impact that such pollution could have on human health.

This study focus on one type of consequence; the loss of consumer welfare experienced by recreational visitors, because of the degradation of the river. More precisely, the emphasis is on the recreational use of the river, namely the economic value of fishing activities. Anglers were the first to act in favor of preservation of the river and are probably still today the most active group concerned[5]. This suggests that they are probably among those who are the most affected by the actual situation.

[1] Fishes' infection is caused by a water mould called Saprolegnia Parasitica. Current biologist studies try to determine whether this parasite has always existed or came from a recent fishes restocking. Also, it is still unknown whether fishes die only because of that, or were already weakened by other factors.

[2] Information transmitted by Mr. Ami Lièvre, chemist. See Fédération cantonale des pêcheurs jurassiens (2004), Kilpéric (2006) and Jeandupeux (2011) for more details.

[3] Since the Châtelot concession was granted in 1954, the government has legally no rights to impose a flow regulation to the firm. Therefore, eventual improvements lie in the hands of negotiators, and this at least until 2024, when the concession ends.

[4] See http://www.parcdoubs.ch/ for more details

[5] As an example, a manifestation to protect the Doubs happened in May 2011, where the majority was anglers.

Rather than directly assess the loss of welfare, this paper reverses the problematic and estimates the benefits that would occur for these people, if ideally the Doubs recovered from its damages. It especially could serve as a first step for a cost-benefit analysis. Indeed, the concerned authorities might see in the results of this study a manner to compare the value of the environmental good with the costs that it implies to restore it. Moreover, this study might be useful to the federal offices of the environment and of energy, since it allows to measure the protection value of a river, regarding its utilization value.

Although interesting, evaluating and determining the policy that would be able to restore the biodiversity in the Doubs is out of the scope of this study. However, I will provide a preliminary step that assesses an ex ante appraisal of the benefits of preserving endangered species.

To evaluate the economic benefits resulting from an improvement in water quality this study uses an extension of the travel cost method, called the hypothetical travel cost method. It is worthwhile to note that this approach does not measure the value of the river to the local economy. Rather than assessing the loss of turnover of restaurants, hostels or other local businesses due to the river's degradation, this study measures the loss of welfare directly affecting individuals.

In the second section, the general background is presented, and the model is explained in section 3. Section 4 presents the survey design and the data. The estimation results are presented and discussed in section 5. Section 6 shows different shortcomings of this study and section 7 finally concludes.

2. Background

The travel cost method (TCM), first suggested in 1949 by Harold Hotelling, uses the number of visits of recreationists to a given site and the costs of traveling to this place to reveal preferences. The TCM is based on the economic theory of demand, where the number of visits is used as a proxy for quantity, and the travel cost is a proxy for price. A demand function can then be estimated. The benefit net of travel costs that each individual gains from being able to visit a site for a given price is called the consumer surplus, that is the difference between what he is willing to pay and what he is actually paying. This methodology permits to evaluate the recreational value of the site.

A commonly used alternative to TCM is the contingent valuation method (CVM), which is the most well-known stated preferences approach. Unlike TCM, it presents the advantage of taking into account the total economic value. It involves the construction of a contingent market and, by asking people to state their willingness to pay, it is possible to perform an ex ante appraisal of a policy, such as the restoration of the Doubs.

The hypothetical travel cost method (HTCM) is used here to take the advantages of both TCM and CVM, and combine stated and revealed preferences. The idea to extend the TCM to the HTCM is proposed by Layman, Boyce and Criddle (1996). They suggest a blend of travel cost and contingent valuation methods. On the one hand a travel cost model is estimated under current circumstances, where preferences are revealed. On the other hand a hypothetical scenario is constructed and it is asked to respondents to state how many trips they would make under this hypothetical situation. The main advantage of the extension is that it allows to do an ex ante appraisal of a change in water quality, unlike the basic travel cost method.

However the measure of the hypothetical scenario comes at the cost of potential strategic responses, the main source of bias under the CVM. Nevertheless, the HTCM can be superior to the CVM in the sense that respondents are more alike to provide plausible hypothetical data since they do not state their preferences directly. Hence, there is less room for strategic answers from respondents. Furthermore, the contingent market is quite simpler than under CVM since the price and payment vehicle is not explicitly stated. In addition, unlike the CVM, the HTCM allows to examine substitute sites. The only shortcoming of using HTCM rather than CVM stands in the fact that unlike the latter, HTCM does not measure the total economic value of an environmental good. Indeed, because this paper is based only on one of the many services that the river provides, it is important to note that the results will not give a complete measure of the total economic value of the Doubs' restoration. Benefits from better water quality and more fish-friendly regulation of the river flow will be measured only from one point of view: the recreational use through fishing activities.

I chose the hypothetical travel cost method applied to anglers because I assume that under a CVM, people of the region, except maybe individuals directly affected, could underestimate this value, especially because fishes may not represent the most popular species in the region[6]. Focusing on anglers allows me to use the travel cost method and link the valuation method to

[6] Further research on the subject could verify this assumption. Indeed, although not used in this paper, the survey comported a section for contingent valuation method, where anglers reported their willingness to pay to offset electricity losses due to hydroelectric power plants regulation (vehicle payment).

revealed behavior. Then, the travel cost method can equally be applied to stated preferences namely reported increases in consumption in hypothetical situations. By comparing the hypothetical values with actual valuations, one can estimate the consumer's benefits of a given improvement. The next chapter presents the model with more details.

3. Model

The form of the hypothetical travel costs method for the recreational fishing demand for the Doubs is given by equation (1).

$$NV_i^k = f(P_{ik}, DHS_{ik}, PS_{ik}, YD_i, Ddoubs_i) \quad (1)$$

Where NV_i^k is the number of visits to the Doubs by individual *i* to site *k*. P_{ik} is the implicit price of travel and opportunity costs to the Doubs faced by individual *i* to visit site *k*. DHS_{ik} is a dummy variable that takes the value 1 if the observations are taken under the hypothetical situation and 0 otherwise. This dummy will allow the actual and the hypothetical number of visits in the Doubs to be distinguished. The number of visits per angler to the Doubs will increase (decrease) depending on whether the fishers expect the hypothetical situation will have a beneficial (detrimental) effect. PS_{ik} is the price faced by individual *i* to visit a substitute site *k* and YD_i is individual *i*'s disposable income.

To these four variables, one control variable has been retained because it showed significant effects on the number of visits[7]. *Ddoubs* is a dummy, which takes the value one if the angler fishes only in the Doubs and zero if fishes also elsewhere.

To construct the dependent variable of the model, that is the number of visits, six questions were asked to each respondent. Anglers reported the number of trips they made in 2010 to up to three different sites in the Doubs, and the number of trips they would have made under the hypothetical improvement, again to three different sites. This permits to treat the data as a panel rather than a cross section. In our case, a sample of anglers is observed under two different situations (actual and hypothetical) and for three different sites. This means that

[7] This choice is based on pairwise correlations between different socio-economic variables and the number of visits. Besides, preliminary regressions have been made trying different combinations of control variables. Only *Ddoubs* showed statistically significant effects.

over the 6 observations by angler, the number of visits and the travel cost are varying, while the other variables stay constant[8].

As frequently computed in the literature, individual *i*'s travel cost is expressed by:

$$P_{ik} = 2\left(\frac{(\text{Distance})(\text{cost per km})}{(\text{group size})}\right) + 2\left(0.25 \cdot \text{wage} \cdot \text{Time}\right) + \frac{\text{license fee}}{\text{Number of Visits}} \quad (2)$$

These determinants are derived from responses to the survey questions. The travel cost equation is composed by direct travel costs (the first term on the right-hand side), opportunity cost of time (the second term on the right-hand side), both multiplied by two to account for a round-trip, and the license fee per trip (last term on the right hand side).

Distance is the number of kilometers separating an angler's departure and the site where he/she fishes. The survey included a question about the distance, but since some answers were inaccurate, all distances were computed using Google maps[9]. For people using a car, the transport cost is then computed by multiplying the number of kilometers by the cost per km given by the statistics of the Touring Club Suisse[10]. Finally, the transport cost is divided by the number of anglers traveling in the same car. Transport cost is assumed to be equal to zero when the individual walks or uses a bike.

The second part of the right-hand side equation represents the opportunity cost of time to go to the fishing site. The correct measure of the opportunity cost of time is highly debated in the literature. The limitations of taking wages as a proxy of this cost are presented by Baranzini & Rochette (2006). First this assumes that each individual is free to substitute any time of labor with leisure time. Second, any inactive person such as unemployed or pensioner, are assumed to have no opportunity cost of time. Despite these strong assumptions, wages are still the most widely used measure for the opportunity cost of time. In this study, a proportion of 25% of the wage rate has been chosen, following Baranzini & Rochette (2006) and Buchli et al. (2002). In the equation (2), the variable *wage* represent the hourly wage that is the annual income divided by 2000. The annual income is given by an open-ended question in the survey that either represents the personal income or the household's income depending on

[8] A more elaborated method would have been to use a random utility model (RUM) for valuing site access and changes in site quality. See Parsons (2003) for further details on this model.

[9] The fastest trip to the site was always chosen. The minimum distance when a fisher went where he actually lives was set to 1km.

[10] The estimation for 2010 for a typical vehicle (new car price of 35'000 CHF and 15'000 km per year) given by the website of the TCS is set to 76 ct/km.

which one the angler is most likely to consider for his/her expenditures. The wage is then divided by 2000 to get the hourly wage rate and multiplied by the travel time. Although the survey asked respondents how many hours they spend to travel and to fish, this information has not been used. Indeed, this question seems to have been confusing for some anglers, who reported a lapse of time even smaller than the travel time itself, while it was supposed to include also the fishing time. Because of that, Google maps was used to compute the minimum travel time to the site, on which I uniformly added 12 minutes to account for preparation or any usual delay.

To these two costs, it is reasonable to add other expenses such as fishing license fee or cost of material such as bait, rod and equipment. Both license fee and equipment expenses were asked in the survey. The licenses considered are primarily used for the Doubs. However, since a majority of angler fish in multiple regions it is difficult to estimate the equipment expenses for the Doubs only. Therefore, only license will actually be added to the travel cost. The license annual fee is divided by the number of visits per year, to have a per visit value.

Travel costs estimates to substitute sites, such as rivers or lakes, are included in the demand equation for fishing trips in the Doubs. These sites also include non-fishing activities. To exclude extremely distant substitution sites, such as trips abroad, I removed all observations with more than a 3.5-hour drive to the site. The price of substitute sites is computed the same way as for the Doubs, excluding however the license fee, for which I do not have any data and which would be irrelevant for non-fishing activities. Since the variable *group size* is unobserved for trips to substitute sites, it is assumed to be the same as for the Doubs.

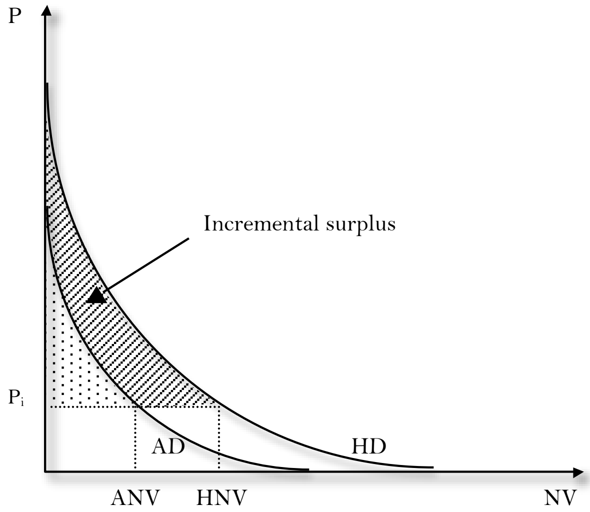
The estimation of a demand function implies the choice of a functional form. Layman et al. (1996) and Buchli et al. (2002) specify the number of visits as an exponential function of travel costs and other explanatory variables. The coefficients of exponential models can be estimated with ordinary least squares by regressing the natural logarithm of visits on the travel cost and other explanatory variables:

$$\ln\left(NV_i^k\right) = \alpha + \beta_P P_{ik} + \beta_{DHS} DHS_{ik} + \beta_{PS} PS_{ik} + \beta_{YD} YD_i + \beta_{Ddoubs} Ddoubs_i \qquad (3)$$

Alpha and betas are the model parameters to be estimated. The variables are defined above. This semi-logarithmic specification is in line with Wieland & Horowitz (2007). This functional form has been preferred to a double-log specification because of the advantage it provides when computing consumer surplus[11].

The consumer surplus represents the benefit that individuals derive from an activity in excess of their participation costs. Therefore, the consumer surplus for fishing in the Doubs is the area below the demand curve and above the travel cost incurred by each individual (P_i).

Figure 1: Variation in consumer surplus



In our case, we compute two different consumer surpluses, one under the current situation and one under a hypothetical improvement in river quality. The benefit of restoring the river, from a recreational point of view, is represented by the incremental surplus on the following figure. On figure 1, AD represents the estimated actual demand for fishing the Doubs, in other words the demand when DHS in (3) equals zero, and HD is the demand that would occur under an improvement of water quality and flow regulation (DHS=0). HNV is the hypothetical number of visits and ANV the number of visits taken in 2010.

The area below the curve is the integral of the demand function, which from (3) can also be written as:

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[11] The double-log specification presents the advantage of mitigating extreme values of both number of visits and explanatory variables, such as travel costs or income which are likely to be subject to extreme values. However, it can be shown that in the case of a double-log specification, the integrated expression does not asymptotically tend to zero, and hence, the consumer surplus will tend to infinity. Thus, the researcher has to make an assumption about the upper value of the price. In most studies, the maximum price of the sample is chosen as an upper value. However, this does not necessarily corresponds to the maximum travel cost over the whole population. In fact, this depends crucially on the survey design. In my case, since I did not limited the area of respondents, the maximum travel cost is very high, and thereby can largely influence the consumer surplus value. Moreover, the individual facing the highest travel cost is a priori not a part of the population of interest, that is people coming from the region of the Doubs. Indeed, any improvement in river quality would probably be paid by the region, and thus, from a political point of view, local anglers are more concerned.

$$NV_i^k = \exp(\alpha + \beta_P P_i + \gamma X) \quad (4)$$

Where P_i is the price, X is a vector of explanatory variables, and α, β_P, γ are the demand function's parameters.

Thus, the consumer surplus for individual *i* is given by:

$$CS_i = \int_{P_i}^{\infty} \exp(\alpha + \beta_P P + \gamma X)\, dP = \left.\frac{\exp(\alpha + \beta_P P + \gamma X)}{\beta_P}\right|_{P=\infty} - \left.\frac{\exp(\alpha + \beta_P P + \gamma X)}{\beta_P}\right|_{P=Pi} \quad (5)$$

Since the coefficient of the price β_P is expected to be negative and $\lim_{x \to \infty} e^{-x}=0$, it is possible to rewrite (5) in a closed-form, as suggested by Wieland & Horowitz (2007) :

$$CS_i = -\frac{\exp(\alpha + \beta_P P_i + \gamma X)}{\beta_P} = -\frac{NV_i}{\beta_P} \quad (6)$$

Thus, the consumer surplus for individual *i*, corresponds to the number of visits he/she took under the current or the hypothetical situation, divided by the coefficient of the price, in absolute values.

The first source of uncertainty comes from the fact that β_P is unknown, and thus has to be estimated with the model (3). Then, the total consumer surplus per year is computed by replacing NV_i by the total number of visits taken to the Doubs in one year. Unfortunately, this information is not available. Therefore, the consumer surplus experienced by a typical angler in the sample will be computed and multiplied by the total number of anglers fishing in the Doubs in 2010. In order to do that, I will compare the results for two different measures of the number of visits[12]:

1. The observed number of visits taken under the actual and the hypothetical situation, i.e. the sum of the number of visits reported to 1, 2 or 3 sites.
2. The number of visits predicted by the model, under actual and hypothetical situation, i.e. the predicted number of visits times the number of sites[13] chosen by the angler.

[12] For measure 1, aggregated data are used. Since each fisher reported up to 3 sites under each situation, the number of visits to these three sites is summed. This method can be criticized, since some anglers may have visited more than 3 sites. In these cases, the actual number of visits is higher than the one reported. To identify these anglers, I used a question asked in the survey about the frequency of the visits of the angler. Since a fishing season lasts 7 months, we can deduce that an angler who fishes twice a month, fished approximately 14 times. Thereby, each angler who reported 3 sites and whose frequency number was higher than the NV reported was considered as potentially problematic. They represented a total of 11% of the sample and removing them does not influence the results (same median and mean=22 instead of 22.71).

[13] Since in measure 2 the predicted value comes from a panel data, it represents the number of visits to one site.

Finally, the total incremental surplus, i.e. the total benefit resulting from an improvement in water quality and flow regulation, can be computed this way:

$$\Delta CS = \left(\frac{HNV_{(\text{observed or predicted})}}{\beta_P} - \frac{ANV_{(\text{observed or predicted})}}{\beta_P} \right) \cdot N \quad (7)$$

Where *N* stands for the number of anglers.

4. Data

The sample was drawn from licensed anglers indicating that they had fished in the Doubs or in other rivers in the same area during 2010. The fishing season 2010 has been chosen as the reference year, first because it was the most recent complete season, allowing respondents to remember their number of visits and second because the Doubs was already in a bad situation but not as critical as in 2011. A survey entitled "Questionnaire sur la valeur du Doubs et de sa faune pour les pêcheurs" was mailed out in French and in German to the concerned fishermen by three different institutions[14] that either directly sent the questionnaire to 2010 licensed fishermen[15] or transferred the information to fishing associations of their respective region. Questionnaires have been collected from May 29th to July 5th 2011.

The survey consisted of 5 pages divided into 4 sections. While the first part covered attitudinal questions, the second part was aimed to expose the hypothetical situation to respondents. The idea was to represent a significant improvement in water quality to observe a change in anglers' behavior. Hypothetical travel cost questions need to provide an easily understood description of the policy option that is of interest. Therefore, one single policy measure was introduced, which is an imposed flow regulation to the hydropower plants. Thereby I assumed one improvement, which aims to abolish the high differences in flow within small lapses of time that currently occur frequently because of hydropower plants. To illustrate this, 2 pictures different from 20 minutes demonstrated these rapid changes in river flow. Although the problem might be well more complex than that, this allows to have a simple policy, understood identically by each respondents. It was then emphasized that such a policy was assumed to be sufficient to lead to an increase in the trout quantity, up to 250

[14] L'office de l'environnement jurassien, le service de la faune neuchâtelois and the french DDT (direction départementale des territoires du Doubs)
[15] as did "L'office de l'environnement jurassien"

fishes per km. According to an experimented angler, this objective measure of water quality would be the sign of a healthy river as was the Doubs several decades ago[16].

In the third part, the anglers reported information concerning their fishing behavior in the Doubs in 2010. Finally, the last part was completed by socio-economic questions.

A total of 265 surveys had been returned, which corresponds approximately to 30 percent of returns. Of these, 40 have been removed of the sample because of lack of information about number of visits. From the 225 observations left, 204 were from people who fished the Doubs in 2010. From the 21 anglers who did not, 19 would actually fish again in the Doubs if water quality would be improved[17].

Table 1 presents the descriptive statistics of the number of visits respondents reported in each situation. These values are going to be used when computing the consumer surplus. Because each angler reported up to 6 different sites, I used here an aggregated approach to compute the actual and hypothetical number of visits. The number of visits to each site is summed over all sites to measure an individual's annual number of visits. This value is the quantity demanded of fishing trips in the Doubs under 2010 situation or under the hypothetical situation. In order to avoid missing too many observations, the actual and the hypothetical number of visits, which are used to compute the consumer surplus, are based on the complete sample (225 anglers).

Table 1: descriptive statistics of the aggregated number of visits

Variable	Obs	Mean	Median	Std. dev.	min	max
Number of visits used to compute consumer surplus						
Actual number of visits in 2010	225	22.71	10	28.78	0	165
Hypothetical number of visits under improvement	225	43.53	30	44.83	0	275

The anglers of the Doubs fished on average approximately 23 times in 2010. However, the median is of 10 visits, suggesting a distribution skewed to the right. This is the case also

[16] Although necessary for the scope of this study, the simplification of the problem arose some critics from respondents who either criticized the fact that I only accounted for the hydropower plants problem, or disapproved the objective measure of water quality that I presented, since for them, trout quantity is not what matters. Because of that, some respondents did not report a significant change in their behavior. However, we will see that even with that shortcoming, demand for fishing in the Doubs still significantly increases under the hypothetical improvement.

[17] Unfortunately, my models do not sufficiently account for these people since we have information on all variables for only 4 of these 19 anglers.

for the hypothetical number of visits, which represent almost twice the number of visits under the current situation. Therefore, we already presume that the anglers see a large beneficial effect from flow regulation and thereby water quality improvement.

Table 2 represents the descriptive statistics of the variables used to estimate the model.

Table 2: descriptive statistics of the variables of the model

Variable	Obs	Mean	Median	Std. dev.	min	max
Variables of the model varying across angler (2-6 observations by angler)						
Number of visits (actual and hypothetical) (NV_i^k)	501	14.77	10	17.79	0.1	150
Log Number of visits (actual and hypothetical) ($ln(NV_{id}^k)$)	501	2.13	2.30	1.12	-2.30	5.01
Travel costs (CHF) (P_i)	501	98.63	65.18	123.78	1.68	1183.86
Variables of the model constant across angler						
Travel costs to a substitution site (PS_i)	106	56.68	23.74	81.18	1.52	438.28
Monthly disposable income (personal or Household, CHF) (YD_i)	106	5637.31	4500	6574.04	204	60000
Doubs (=1 if fish only in the Doubs) (*Ddoubs*)	106	0.20	0	0.40	0	1

On the 225 anglers from the database, 3 were younger than 18 years old. These observations are omitted because expenditures of young people are often not directly supported by themselves. Then, 16 anglers are excluded because of the substitution site they reported, used to compute the substitution price variable. Indeed, since a few people reported that they would go fishing abroad (Slovenia, Austria), distant substitution sites (more than 3.5 hours drive) have been excluded because they are not considered as direct substitutes to the Doubs. Finally, because 100 anglers did not give sufficient information about the explanatory variables, the regression is based on 106 anglers. Each individual is visiting up to 3 sites in two different situations, implying 2 to 6 different observations of number of visits and of travel costs.

The dependent variable of the model is represented by the log of the number of visits under current and hypothetical situation ($ln(NV_{id}^k)$). The logarithm allows to mitigate the heteroscedasticity problems related to extreme values and right-sided distribution characteristics of the number of visits. In order to account for zero number of visits and since the logarithm of zero is not defined, all zero values were replaced by 0.1. This could seem ad hoc, but it is useful to know whether the zero observations affect the results[18].

The variable of interest, the travel cost (P_i), shows an average around 100CHF, which is quite high but mostly affected by a few extreme observations, that is anglers coming from very far away. Only 9 from the 225 respondents have to travel more than 500 km to the Doubs, with a maximum of 1070 km.

To build the travel cost variable to substitution sites (PS_i), people chose themselves the site and the activity that would be the most appropriate for them, if it would not be possible to fish in the Doubs anymore. The substitution activity is not necessarily fishing.

The variable *Ddoubs* distinguishes people who fish only in the Doubs from the others. 20% of anglers who answered the questionnaire and who have been retained in the regression fish in no other rivers or lakes than the Doubs.

5. Results

The results of the Hausman test show that we can reject the random-effects (RE) model at a 1% significance level in favor of the fixed effects (FE) model. However, the coefficients of respondent's characteristics, such as income or substitution travel cost variables, are no longer identified with fixed effects estimation. To overcome this problem, correlated random effects, suggested by Mundlak and Chamberlain[19], were used. Basically, adding two variables to the model (DHS and P)[20], that is the average by fisher of the variables varying across angler, allows to get the same coefficients as fixed effects (β_P), without losing information about the angler-invariant variables coefficients.

Using generalized least squares (GLS), the model is estimated as follows:

$$\ln\left(NV_{ik}\right) = \alpha + \beta_P P_{ik} + \beta_{\bar{P}} \bar{P}_i + \beta_{DHS} DHS_{ik} + \beta_{PS} PS_{il} + \beta_{Ddoubs} Ddoubs_i + \beta_{YD} YD_i \quad (8)$$

$$\text{Where for our case}: \bar{P}_i = \frac{1}{6}\sum_{k=1}^{6} P_{ik}$$

The results of the estimation of equation (8) are provided in table 3.

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[18] Several values to approximate NV=0 have been chosen such as 0.01, 0.5 and 0.1, as retained here. Again the coefficients were not much affected by these changes (coefficient are the same until the 3rd decimal)

[19] For further details about Correlated random effects (CRE) and its advantages over FE, see Wooldridge (2009)

[20] The fisher average for the DHS variable should also be added in theory. However, the average of DHS would always equal 0.5 and thus it is a constant. This a priori explains why the coefficients of DHS under FE and CRE are slightly different. However, this difference will have no impact on consumer surplus results.

Table 3: Estimation results
Correlated random effects (semi-log GLS)

Dependent variable: $\ln(NV_{ik})$ Explanatory variables:	Estimated coefficients:
P_{ik} (Travel costs)	-0.012*** (0.002)
$\overline{P}_i$	0.010*** (0.002)
DHS (dummy for hypothetical situation)	0.666*** (0.073)
PS_i (Travel cost to a substitution site)	0.002* (0.001)
Ddoubs (dummy for fishing only in the Doubs)	0.466** (0.19)
YD_i (Disposable income)	-0.000 (0.000)
Constant	1.787*** (0.123)
Number of observations (2-6 observations per group)	501
Number of groups (anglers)	106
R^2 overall	0.21
R^2 within	0.29

Robust standard errors in parenthesis, *,**,***=significantly different from zero at the 90, 95 and 99% confidence level.

The goodness-of-fit (overall R^2) implies that the model explains more than one fifth of the overall variance in number of visits, while the within R^2 indicates that 29% of the within-individual variance is explained by the independent variables. This is reasonable given the number of observations and the cross-section data characteristics. Moreover, the variables are for most of them significant and show the sign and magnitude suggested by theory.

The price coefficient, under a semi-log specification is interpreted as the semi-elasticity of the demand with respect to the price. An increase in travel cost of 10 CHF would, *ceteris paribus*, push the angler to decrease his number of visits by 12%. Using the same model, but estimating a double log specification, allows us to compute the elasticity. In this case, the model suggests that a 1% increase in the travel costs implies a 1% decrease in the number of visits. Because the 95% confidence interval ranges the coefficient from -1.22 to -0.77, we cannot conclude on the elasticity as it could be elastic (<-1), unit elastic (-1) or inelastic (>-1).

As explained earlier, the correlated random effects estimation gives the same coefficient for price as under fixed effects. If the coefficients of $\overline{P}_i$ and travel cost estimated under correlated random effects are summed, we get the RE coefficient of price (-0.002). It is interesting to note that the average travel cost coefficient (+0.010) shows almost the same magnitude as the travel cost coefficient (-0.012), but has a positive impact on the number of visits. This is explained by endogeneity, that is more interested people not only have higher number of visits, but they also go farther and face higher travel costs. Indeed, this effect explains why the RE estimators, without considering this correlation, would be biased.

The DHS coefficient informs that the demand's intercept would shift by a positive and statistically significant amount as a result of an improvement in water quality. As expected by theory, the coefficient of the travel cost to a substitute site has a positive sign, and is significant at 95% level. This means that the closer an angler lives from a substitute activity, the lesser he will go to fish in the Doubs. Quite intuitively, an angler who has no alternative to the Doubs to go fishing will have a larger number of visits than someone fishing also elsewhere as it is predicted by the coefficient of the variable *Ddoubs*. Finally, the income coefficient shows a counter-intuitive sign, but is however not significant. According to the economic theory, we would expect a higher demand for visiting the site if the income is higher, ceteris paribus. However, according to the model, the individual income has no influence on the number of visits. Although surprising, this result has been noted in many other studies dealing with recreational use of the environment, such as Buchli et al. (2002) and Baranzini & Rochette (2006). Other socio-economic variables, such as education, age, or the fact of being inactive, have been added. However, since their coefficient was not significant, they have been omitted in the final model.

Thanks to the results reported in table 3, it is possible to compute the consumer surplus occurring for each individual under the actual and the hypothetical situation. Table 4 provides first a review of the number of visits reported by respondents and predicted by the model.

Table 4: Reported and predicted number of visits

	Reported NV		Predicted NV	
	Mean	Median	Mean	Median
Actual situation (ANV)	22.71	10	15.43	15.03
Hypothetical situation(HNV)	43.53	30	34.96	32.83
ΔNV	+20.82 (+92%)	+20 (+200%)	+19.53 (+127%)	+17.80 (+118%)

The distribution of the reported number of visits is highly skewed to the right, implying lower values for median than mean. Although there is almost no difference in the increase in number of visits in absolute terms (resp. 20.82 and 20), it follows that the increase in the number of visits is less than doubled when taking the mean, while it is tripled with median values. Quite intuitively, such a difference is not happening when predicting the number of visits, given the fact that fitted values follow a normal distribution. Indeed the number of visits increases by little less than 20, and is more than doubled, regardless whether we take median or mean. This suggests that predicted mean accounts less for the several extremely large number of visits than does the average of the reported number of visits.
Dividing the number of visits by the estimated coefficient of price (-0.012) allows to get the consumer surplus by angler, reported in table 5. The incremental consumer surplus (ΔCS), that is the benefit per angler of improving water quality and flow regulation, ranges from 1450CHF to 1697CHF.

Table 5: Consumer surplus (CS) and benefit estimations by angler per season (CHF)

	Reported NV		Predicted NV	
	Mean	Median	Mean	Median
Actual situation CS	1851	815	1258	1226
Hypothetical situation CS	3548	2445	2850	2676
ΔCS	**+1697 CHF** (+92%)	**+1630 CHF** (+200%)	**+1592 CHF** (+127%)	**+1450CHF** (+118%)

Consumer surplus based on predicted values yields to reliably smaller benefits. Bockstael et al. (1990) explain this by the regression error, that is omitted variables or measurement error. Although this might be the case here, it is reasonable to rely upon both results since what matters for benefit valuation is incremental surplus (ΔCS), which does not vary much between observed and predicted values.

Except for the median reported number of visits, consumer surplus under the actual situation is higher than in other studies. For instance Buchli & al. (2002) reported CS=925 CHF for the Ticino river and Baranzini & Rochette (2006) find 1135 CHF for an evaluation of a forest using traditional travel cost method for the latter. It is interesting to go further in the comparison with Buchli et al. (2002), since the present study has been inspired by their survey, as well as their methodology (HTCM). The incremental surplus found by Buchli et al.

(2002) equals 440 CHF, which is much smaller than the result of this study, although the price coefficient is similar (-0.01). First, although Buchli et al. (2002) used aswell a semi-log form, they fixed an upper value for the integral, by arguing that the intercept with the price axis is only asymptotic. Because of that, their consumer surplus computation is already smaller[21].

Second, consumer surplus values are distinct because of the number of visits, suggesting that the situation is different for the two rivers. In the case of the Ticino River in 1998, the situation was not as critical as today for the Doubs. This is on one hand illustrated by the actual number of visits, which is on average smaller for the Doubs than for the Ticino River. On the other hand, although the hypothetical situation[22] described was the same in both cases, the number of visits increases less than 40% for the improved situation in the Ticino River, while it is more than doubled in the case of the Doubs[23]. As a result, we can mostly interpret the high values for the Doubs by its highly critical situation, implying a massive loss of welfare for the anglers[24].

6. Limitations

The travel cost method suffers from the inclusion of multiple purpose trips, that is people coming to the Doubs and doing more than fishing, for instance visiting family or enjoying restaurants, site-seeing, etc. This is problematic since the price they pay to travel to the Doubs should not be totally imputed to the river's value, and estimates are likely to be biased upwards. This problem is well known but there is no obvious way to identify the portion of travel cost that should be imputed to fishing and the portion that should be attributed to other purposes. Therefore, it is assumed that either all trips are single-purpose, which is what was done here, or the potential multi-purpose trips must be dropped. To do that, Parsons (2003) suggests that overnight trips are potentially subject to multi-purpose trips. According to this author: "In a day-trip model of recreation use, a safe bet for the extent of the market is a maximum day's drive to reach the site—perhaps three to four hours[25]."

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[21] Indeed, relying on their observed actual number of visits (26) and hypothetical number of visits (36) to compute the consumer surplus in the same way it is done here, an incremental consumer surplus around 1000 CHF is obtained.

[22] The improvement is the same in terms of fish quantity (250 trout per km).

[23] This difference is also visible in the coefficient of DHS, which equals 0.39 in Buchli et al. (2002). The difference of total benefit per year will also be larger since Ticino River registers 3000 anglers, while approximately 30'400 anglers are fishing in the Doubs.

[24] Another explanation could be inflation. If we index the 1000 CHF we found for Buchli et al. (2002) (using CPI annual mean from SFOS), we would get 1073 CHF in 2010. In this study, the comparable incremental surplus (1697 CHF) is still higher.

[25] Parsons (2003), p. 277

Therefore, consumer surplus has been computed with the same model as before, but without individuals driving more than 3.5 hours to reach the Doubs. The first difference in the results[26] lies in the fact that the control variable D*doubs* is no longer significant. It is also useful to note that although 20 observations were dropped in the process, both overall and within R^2 increase (respectively 28% and 37%). Similarly, both price coefficient's significance and magnitude increase. As a result, the benefits are smaller and range from 1374 CHF for the median predicted value to 1520 CHF for the average predicted number of visits[27].

Other limitations rely first on the travel cost method used in this paper. A posteriori the survey was missing a question about the time length, that is the number of days per trip. Indeed, many studies have generally found that people who travel long distance take fewer but longer trips. If information about number of day per visit would have been available, this would have allowed to compute the consumer surplus per day, which can subsequently differ from consumer surplus per trip, and thus per year.

Second, the way price was computed here is not the single option possible. Whether opportunity cost should be included, and if so using which proxy, is still highly debated. The way of defining the substitution site can also be diverse. It depends on the activities we consider as close substitutes. Here, respondents' choices were used, although some might be non-fishing activities. Other studies would have maybe dropped non-fishing activities of substitution price variable.

Finally, some respondents reported in the survey their concern for the fact that increased number of visits would actually have adverse effects on future trout stocks. This points towards a conceptual issue, that is the role of site congestion, reminding that the travel cost literature still needs further research on a few key subjects.

Sample selection bias is another shortcoming that characterizes this study. Indeed, this comes from the fact that people who answered the questionnaire are in general more interested to the good in question (i.e. the quality of the Doubs) than the population in

[26] not reported here

[27] Assuming that distant anglers are more likely to have multi-purpose trips than the anglers living closer to the river may not be verified. Indeed, for instance the latter are more likely to have family in the region. Hence, one has to keep in mind that dropping extremely distant anglers does not entirely solve the problem and this is why we keep the results of the previous section. One solution would have been to ask in the survey whether the anglers have other activities near the Doubs than fishing.

general. The problem is that we do not have information about non-interested people. This implies a possible overestimation of the environmental good value.

Sample selection models first consider the decision of an individual to participate or not, which is called the participation decision. Then the model predicts how many times an individual will come, given the fact that he decided to participate. This is the quantity decision. These models are possible to estimate first, when the zero observations are sufficiently numerous in order to explain the participation decision. Second, determining factors for both participation and quantity decision have to be found, although they might not be the same in both steps. In fact, one variable has to be specific to the selection stage to guarantee identification of the model[28]. Since the first condition was not verified in our sample, using these models is inappropriate, although sample selection bias probably remains in the results.

Finally, recent papers using travel cost method treat the number of visits as a discrete variable using count models, such as Poisson or negative binomial. However, Wieland & Horowitz (2007) argue that lognormal models may still have key advantages. Indeed, they found that log specification "provides a good fit for trip distributions that include many small numbers of trips and a few very large[29]", which is what characterizes our sample. However, estimating a negative binomial model or alternative discrete choice models will be the next step in order to check the robustness of the results to different estimation methods.

7. Conclusion

This paper aimed at evaluating the angler's benefit resulting from an improvement in water quality and flow regulation in the Doubs. The river is facing pollution problems from human activity and large flow variations imputed by hydropower plants, resulting in a critical threat to the river's biodiversity. In this context, it was crucial to have an estimation of the economic benefits of a restoration, in order to countervail the associated costs.

The economic valuation of the recreational use was a helpful approach to measure part of these benefits. The hypothetical travel cost method has been used, where anglers were asked to report their behavior under the actual situation (fishing season 2010) and under a situation with a hypothetical improvement of the river's flow. A survey has been sent to all the anglers

[28] See for instance the Heckman model used by Buchli et al. (2003).

[29] Wieland & Horowitz (2007), p. 3

who fished in the Doubs or in other rivers in the region in 2010. Since each angler reported her number of visits to 1-3 sites, the data has been structured as a panel data set. Correlated random effects were used to estimate the model, which is a novelty in the travel cost literature.

The estimation results showed a semi-elasticity of demand of -0.012 with respect to price, i.e. an increase in total travel costs (including transport cost, opportunity cost of time and license fee) of 10 CHF would incite a typical angler to decrease his number of visits by 12% on average. There were approximately 30’400 anglers in the Doubs in 2010. Estimated annual benefit, resulting from an improvement in water quality and flow regulation, ranged from 1450 CHF to 1700 CHF per angler. Taking the average of the two range limits, the annual benefit of the restoration of the river approximates to 48 Mio CHF. This benefit is expressed in terms of anglers’ welfare gain and not necessarily translated into monetary exchanges. These are high values compared to similar studies, such as Buchli et al. (2002) for the Ticino River. The difference can be explained partly by a difference in consumer surplus’ estimation. Also, the number of anglers in the Doubs is larger. The rest of the difference can be imputed to the critical situation of the Doubs, implying large losses of welfare.

Sample selection bias and multi-purpose trips’ problem might imply an overestimation of the recreational value. On the other hand, the model does not include additional effects such as the welfare of non-angler visitors as well as newly attracted anglers. Moreover, one should keep in mind that the recreational fishing use is only a small part of the total economic value of the Doubs. Other environmental services, such as the satisfaction of knowing that species live in the river, are not considered in this paper. A complete measure of the river restoration benefits should also include long-term ecological impacts, as well as human health implications. However, an ex ante appraisal of a relatively well-defined part of these benefits may still be useful for policy makers to make preliminary comparisons with the entailed costs.

Implementing a policy for a complete restoration of the river would probably imply important costs, given the complexity of the situation and the numerous entities involved. Although these costs might not be known precisely, the benefits of restoration estimated in this study are sufficiently large to suggest that at least a few rapid actions would be easily offset by the benefits. Finally, it is also important to note that rivers such as the Doubs are exploited to generate “green” electricity. The results of this study suggest that such productions could induce considerable externalities that deserve attention.

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