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Master Thesis

Estimating the Benefits of an Improvement in Water Quality and Flow Regulation:

Case study of the Doubs

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Abstract

This paper evaluates the benefit resulting from an improvement in water quality and flow regulation in the Doubs, a river at the border between Switzerland and France. 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 current situation (2010) and under a hypothetical improvement. Thus, 225 anglers stated in a mail survey (June 2011), 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. This method allows a better control for unobserved heterogeneity. By comparing consumer surplus estimations under the two situations, the annual benefit of an improvement in water quality and flow regulation 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 eventual costs of restoration.

Key words: Recreational demand, environmental benefits evaluation, water quality, hypothetical travel cost method, correlated random effects, river flow.

Résumé

Cette étude évalue les bénéfices résultant d'une amélioration de la qualité de l'eau et de l'écoulement des flots dans le Doubs, une rivière à la frontière entre la Suisse et la France. Aujourd'hui, la biodiversité du Doubs est menacée par la pollution et par de larges variations de débit provoquées par les éclusées des centrales hydroélectriques. La méthode des coûts du trajet hypothétique est utilisée pour estimer la valeur économique de la pêche récréative dans le Doubs dans la situation actuelle (2010) et dans la situation d'une hypothétique amélioration. Ainsi, 225 pêcheurs ont reporté dans un questionnaire (juin 2011), leur comportement dans les deux situations. Comme chaque pêcheur a reporté son nombre de visites jusqu'à 3 différents sites de pêche, un panel est estimé par la méthode des effets aléatoires corrélés. Cette méthode permet de mieux contrôler l'hétérogénéité non observée. En comparant les surplus du consommateur dans les deux situations, le bénéfice d'une amélioration de la qualité de l'eau et de l'écoulement des flots est estimé entre 1450 CHF et 1700 CHF par pêcheur et par année. Etant donné que la valeur récréative est seulement une partie de la valeur économique totale de la rivière, ces estimations ne sont pas suffisantes pour donner une mesure complète du bénéfice résultant d'une restauration de la rivière. Cependant, une appréciation ex ante d'une partie du bénéfice total peut tout de même être utile aux autorités pour les comparer aux coûts qu'implique une restauration.

Mots-clés: Demande usages récréatifs, évaluation bénéfices environnementaux, méthode des coûts du trajet hypothétique, effets aléatoires corrélés, débit de l'eau.

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1. Introduction

The Doubs is a river of 453 kilometers, mainly located in France and builds the natural border at the northwest of Switzerland. Thus, a few dozens kilometers of the river are situated in the Swiss cantons of Jura and Neuchâtel.
For a few decades now, biodiversity and biological quality of the Doubs have been threatened. According to a study published in 2004[1], trout and grayling catches in the canton of Jura have fallen by 70% in 15 years. Other species such as the apron or "le roi du Doubs," known to scientists and biologists for their scarcity, are also endangered. The situation is even more critical since January 2011, as many species have been dying in the Doubs, for reasons still not clearly identified[2].

The principal causes of the river's general degradation since 1970's have been studied carefully[3]. 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 more and more toxic substances from industry, such as heavy metals, as well as household's waste, less and less biodegradable. In addition, throughout this period, and the situation is even worse for four or five years now, hydropower plants such as the dam of the Châtelot have imposed almost daily hydro peaking. As a result, species have experienced undesirable variations in water levels, which has caused extensive damages everyday on fishes and benthic animals (fishes' food). Finally, for the last ten years, the Doubs has contained, like other European rivers, more and more micro-pollutants resulting from human activity (medicines, personal care, birth control pills, etc.) or from agriculture and intensive forestry (pesticides, substances used for treating wood). The last knockout in time comes from the acquisition of the Châtelot by the group E[4], four years ago. They impose even more frequent and violent flow variations than the previous operators to make maximum profit at electricity peak times, without regard to the river. Since the concession was granted in 1954, a time when environmental impacts were not such a preoccupation, the government has legally no rights to impose a flow regulation to the firm. Therefore,

[1] Fédération cantonale des pêcheurs jurassiens (2004)

[2] 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.

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

[4] Electricity distributor in the French-speaking part of Switzerland.

eventual improvements lie in the hands of negotiators, and this at least until 2024, when the concession ends.

The situation is even more complex since none of these previous factors is able to explain by itself the degradation. Moreover, the problem is considerable, since the river lies in a natural reserve of national importance — there even exists a project of a regional natural park[5]— and even 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 even more important effects, when we think about the impact that such pollution could have on human health.

This study's focus is 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[6]. This suggests that they are probably among those who are the most affected by the actual situation.

In this context, it is interesting to economically assess a value of this loss of welfare. In other words, I will estimate 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.
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. Moreover, this study might be useful to the federal offices of the environment and of energy, since it allows to assess quantitatively the protection value of a river, regarding its utilization value.

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

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[5] See http://www.parcdoubs.ch/ for more details
[6] As an example, a manifestation to protect the Doubs happened in May 2011, where the majority was anglers.

method. It is worthwhile to note that this approach does not measure the value of the river to the local economy, which is a different concept. Indeed, rather than assess the loss of turnover of restaurants, campings, 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, I explain the importance of an economic valuation of the environmental goods and the different methods that can be used. The third section describes how we can extend the travel cost method to the hypothetical travel cost method, and thereby account for change in water quality. The forth section gives details about the construction of the model. The fifth and the sixth sections present the data collection and the results, while the seventh part highlights the different limitations of the model and the method used. Finally, the eighth section contains the conclusion.

2. Economic valuation of the environment

The rationale of valuing environmental goods

Environmental goods usually provide a range of services to the society. A possible classification of these services is presented in figure 1. Because of their public good characteristics, these services risk to be mismanaged. This often leads to a suboptimal social welfare, and it is rational for governments to intervene, in order to protect environmental goods and the services they procure to society. However, in order to act appropriately, policy makers need information on the value of these services. This is the first reason why valuing environmental services is an important branch in environmental economics.

Second, imagine that policy makers in French and Swiss regions around the Doubs decide to act in order to regulate hydropower plants and decrease pollution resulting from agriculture. This project will necessarily affect a large number of people, making some better off and others worse off. Ideally, the policy producing the largest possible net benefit should be chosen. However, in order to do that, the benefits of such a policy (e.g. anglers welfare gains) need to be measured in monetary terms, in order to be compared to the costs it implies (e.g. loss of profits of electricity company). Thus, while one could think that reducing the environment to a monetary value is too simplistic, one could argue that money is simply "a medium of exchange, a convenient way to add together or compare disparate goods[7]".

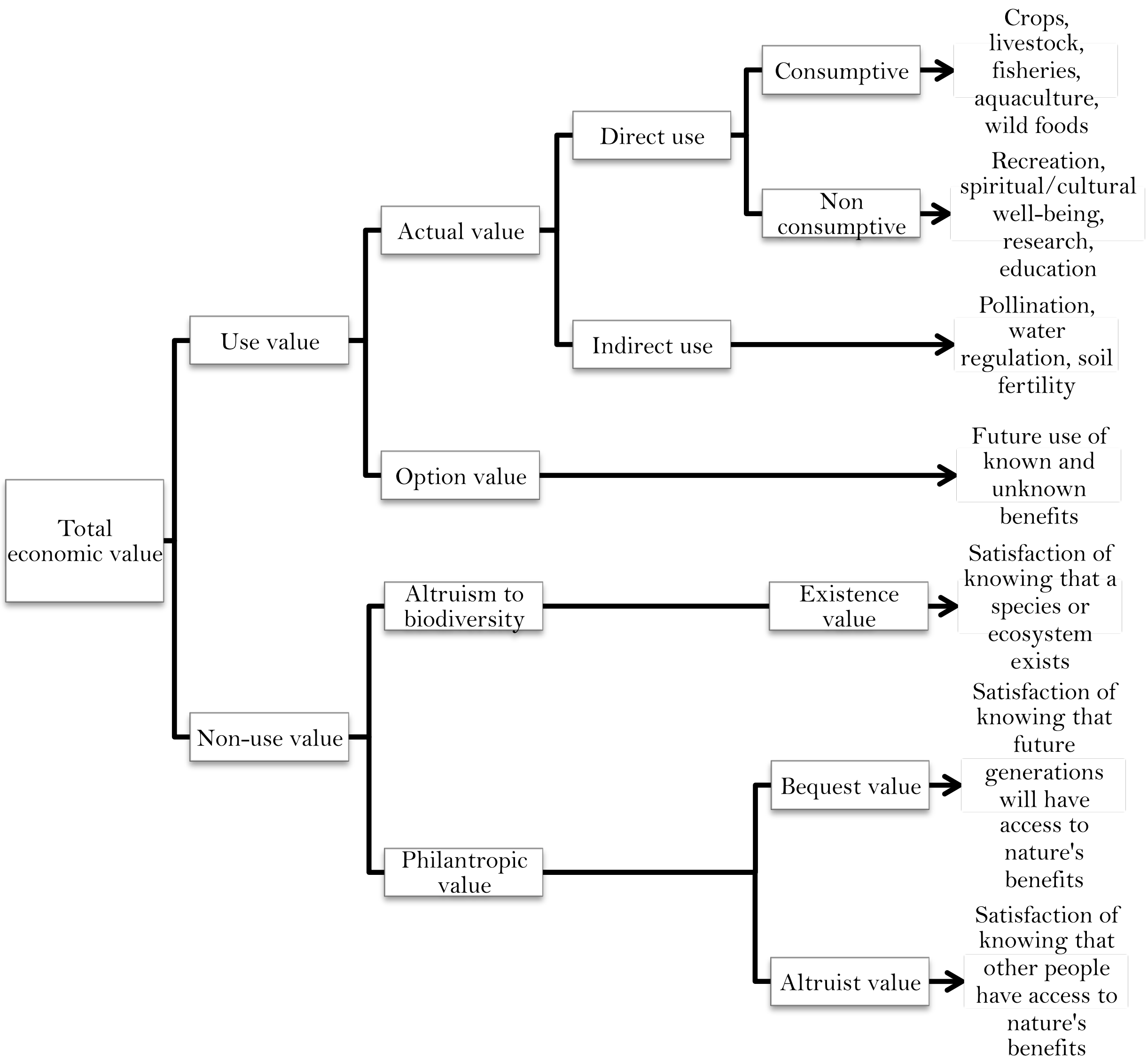
Total economic value

The total economic value of an environmental good is given by the sum of all the services it provides to the society. If we illustrate figure 1 by the case of the Doubs, consumptive direct use will be trout and other fishes. Although fishes no longer directly generate income, they used to be the specialty of many restaurants on the river's border, several decades ago. However, for years, the threat of these species has forced restaurants to replace freshly caught trout from the Doubs with farmed trout. As a result, the direct consumption has considerably decreased because of these species scarcity, and may even have disappeared.

[7] Fullerton, D. & Stavins, R. (1998)

Indeed, only the individual consumption of the anglers remains in this category of service, and many anglers no longer consume the fishes they catch[8].

Figure 1: Total economic value composition



Source: Inspired by Figure in Pavan S. et al. (2010), p. 14

Non-consumptive use of the biodiversity in the Doubs is mostly but not exclusively, fishing activities. Indeed, the river is famous for several rare species, such as the apron, attracting many biologists and other scientists into the region.

Although not insignificant, indirect use values, such as water regulation provided by these species, option value and non-use values, such as simply the satisfaction of knowing that they exist, are more difficult to measure in an objective manner.

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[8] Some anglers stated that they fish and release fishes thereafter, which is called a "no-kill" fishing activity.

Because this paper is based on only one of the many services that the nature 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; from the recreational use through fishing activities. This choice is driven by a comparison of the methods existing to evaluate environmental goods. None of them presents only advantages, and the reason why travel cost method has been preferred is explained in the following subsection.

Nonmarket valuation methods

A non-exhaustive list of environmental goods valuation methods is given in figure 2. The first group of valuation methods is based on market information, such as price-based methods. In my case, it would approximately be reduced in the trout price and its market demand. However, as explained above, Doubs' fishes are no longer sold on the market, hence should be valued by non-market valuation methods. These methods are based on indirect valuation of goods through consumers' preferences, either revealed by their behavior or stated in surveys.

Figure 2: Environmental goods valuation methods

Approach		Method	Value estimated
Market valuation	Price-based	Market prices	Direct and indirect use
	Cost-based	Restoration cost	Direct and indirect use
	Production-based	Production function approach	Indirect use
Stated preference		Contingent valuation	Use and non-use
Revealed preference		Travel cost method	Direct use
		Hedonic pricing	Direct and indirect use

Source: Inspired by figure in Pavan S. et al. (2010), p. 24

The contingent valuation method (CVM), the most well-known stated preferences approach, 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. In our specific case, this could have been the best alternative to the hypothetical travel cost method, since it allows changes in water quality to be taken into account.

However, I chose the travel cost method (TCM) applied to anglers because I assume that 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[9]. Focusing on anglers allows me to use the travel cost method and link the valuation method to revealed behavior.

The main advantage of this method over the contingent valuation method is that people do not state their preferences directly. Hence, there is less room for strategic answers from respondents. Indeed, by observing individuals behavior, the travel cost method permits to understand their preferences and assign a value to their consumptions.

However, unlike the CVM, the basic TCM does not allow to do an ex ante appraisal of a change in water quality. Therefore I opt for the hypothetical travel cost method (HTCM) which permits to combine stated and revealed preferences. Indeed, 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. This approach is discussed in further details in the following chapter.

[9] 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).

3. The travel cost method: literature review and extension to the hypothetical travel cost method[10]

The travel cost method

Observing the number of visits of recreationists to a given site and the costs of traveling to this place, permits to reveal preferences. People living very far from a recreation site, will come less frequently because they face larger costs, and vice versa for people living closer. This can be easily explained by the fact that traveling implies a cost in terms of transport and travel time. Hence, the travel cost method 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.

Brief literature review

The travel cost method is first suggested in 1949 by Harold Hotelling, in a letter to the US National Park service. At that time, there already was a need to assess the monetary value of recreation. Hotelling was the first to think about the travel cost as an expenditure, and thus as a proxy of the recreation price. From this, it is possible to estimate a demand curve and derive the consumer surplus, a measure of welfare.

The idea has been exploited in 1959 by Clawson, who developed the travel demand model. In the 1980's, a few authors, such as Adamowicz (1989) compared the differences in consumer surplus estimates, resulting from different functional forms, and used Monte Carlo simulation to compare these variations.

In 1991, Hellerstein used count data models in his travel cost analysis. He found that Poisson and Negative binomial models gave better results than semi-log models with all zero observations dropped[11]. This work has been followed in 1993 by Hellerstein and Mendelsohn, who developed a theoretical foundation for count data models to account for

[10] This section heavily draws on Babu & Suryaprakash (2008)

[11] As we will see later on, Wieland & Horowitz (2007) observed the reverse in some cases.

the count and non-negative nature of trip making. Therefore, in most recent studies, discrete models are preferred to continuous functional form.

Extension of the travel cost method to the hypothetical travel cost method (HTCM)

The idea is suggested by Layman, Boyce and Criddle (1996), who propose 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 model extension is that it allows to evaluate a hypothetical situation, unlike the traditional travel cost method.
Furthermore, the contingent market is quite simpler than under CVM since the price and payment vehicle is not explicitly stated. However the ex ante appraisal possibility 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 typically have a history of using the resource. In my case, this is even more plausible due to the fact that the hypothetical situation might be a true memory for some anglers. Indeed, the older may remember how they behaved when the Doubs was still in a good situation. Finally, unlike the CVM, the HTCM allows to examine substitute sites.

A similar method has also been used by Heyes and Heyes (1999), called contingent activity model, to estimate consumer surplus. Rather than affecting the number of visits, the contingent market influences the travel costs. Respondents are asked about the maximum additional time they would be ready to travel to reach the site if the latter was further from the current location.

I will rather base my study on the method used in Layman et al. (1996), allowing for changes in water quality and flow regulation. The next chapter presents the model with more details.

4. Methodology

Survey design[12]

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 a 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[13] that either directly sent the questionnaire to 2010 licensed fishermen as did the environmental office of the canton of Jura, 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, I introduced one single policy measure, 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 I presented 2 pictures different from 20 minutes, demonstrating these rapid changes in river flow. Although the problem might be well more complex than that, this allows to have a simple policy, understood the same by each respondents. To that I added an objective measure of water quality by presenting the assumption that such a policy would hypothetically lead to an increase in the trout quantity, up to 250 fishes per km. According to an experimented angler, this would be the sign of a healthy river as was the Doubs several decades ago.
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

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[12] See Appendix 1 for more details on the survey.

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

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.
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[14].

Model specification

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

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

Where NV_i^k is the number of visits to the Doubs by individual *i* to site *k*. P_{ik} is the implicit price or 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 for a given site *k* and YD_i is individual *i*'s disposable income.
To these four variables, it is possible to add socio-economic variables concerning the individuals. After trying different combinations of variables, two control variables have been

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

retained because they showed significant effects on the number of visits[15]. *Ddoubs* is a dummy, which takes the value one if the angler fishes only in the Doubs and zero if fishes also elsewhere, and *Ddperiod* equals one if the angler fishes only during weekends.

Grouping the data

To construct the dependent variable of my model, that is the number of visits, six questions were asked from 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 over the 6 observations by angler, the number of visits and the travel cost are varying, while the other variables stay constant[16].

Travel costs

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

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

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

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

[15] 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* and *Dperiod* showed statistically significant effects.
[16] 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.

were inaccurate, I computed all the distances using Google maps[17]. 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[18]. Finally, the transport cost is divided by the number of anglers traveling in the same car. The 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, I take a proportion of the wage rate as the opportunity cost of time. Following Baranzini & Rochette (2006) and Buchli et al. (2002), 25% of the wage has been chosen. 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 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 license 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

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

[18] 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.

cost[19]. 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 of the same area, or of other regions, 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.

Functional form

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:

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

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 (see the following two subsections).

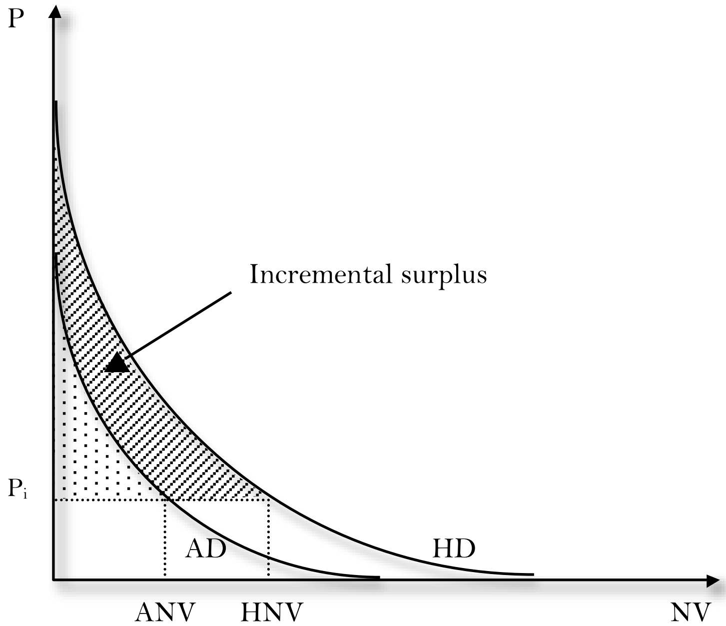
Consumer surplus

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

[19] The inclusion of the license fee might be problematic since the only observation we have is under the actual situation. Indeed, we do not know whether an angler who would go fishing more often under the water improvement situation would buy other or more licenses with different prices. Indeed, there are many license possibilities to fish in the Doubs: seasonal license for the Swiss Doubs (office de l'environnement jurassien or office de la faune neuchâtelois), seasonal license for the « Doubs franco-suisse », seasonal license for the « Doubs français », or day licenses. However, as we will see in the statistic descriptive part, dividing the license price by the number of trips minifies variations.

area below the demand curve and above the travel cost incurred by each individual (P_i). In our case, we compute two different consumer surpluses, one under the current situation and one under a hypothetical improvement in river quality. Then, the benefit of restoring the river, from a recreational point of view, is represented by the incremental surplus on the following figure.

Figure 3: Variation in consumer surplus



AD represents the 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:

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

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:

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

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 thanks to 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, I will compute the consumer surplus experienced by a typical angler in the sample and multiply it 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 measure of the number of visits[20]:

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[21] chosen by the angler.

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:

[20] 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 do not influence the results (same median and mean=22 instead of 22.71).

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

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

Where N stands for the number of anglers.

The advantage of the semi-log form in computing consumer surplus

The double-log specification, that is taking the logarithm of both sides of the equation 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.

The number of visits under a double log-specification, is expressed by the following equation:

$$NV_i^k = \exp(\alpha + \gamma D) \cdot (P_i)^{\beta_P} \cdot (Z)^{\beta_Z} \qquad (8)$$

Where D is the matrix of the dummy variables, from which we do not usually take the logarithm, and Z are other variables such as income or substitution travel costs. Because the coefficient of the price is not in the exponential parenthesis, as it was in (4), it is not possible to simplify the integral of (8) in a closed form with a double-log specification:

$$CS_i^k = \int_{P_i}^{\infty} \exp(\alpha + \gamma D) \cdot (P)^{\beta_P} \cdot (Z)^{\beta_Z} \; dP \qquad (9)$$

Since the integrated expression does not asymptotically tend to zero, consumer surplus under (9) 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. As a result, the main shortcoming of double-log specification comes from the fact that consumer surplus computation cannot be simplified in a closed form, as it is in a semi-log form.

5. Descriptive statistics

Respondents characteristics

Table 1 presents some variables of the survey, which were not used in the model.

Table 1: Respondents characteristics

Variable	Obs	Freq.	Percent	Mean	Std dev.	min	max
Age	223	-	-	48.72	14.37	13	81
Household (number of members)	220	-	-	2.78	1.32	1	9
Education level	214			1.74	0.96	0	3
0=elementary school		10	4.67				
1=apprenticeship		103	48.13				
2=maturity		33	15.42				
3=university		68	31.78				
Rent of house/flat (CHF)	173	-	-	1059.91	572.25	0	3000
Environmental association	224			0.26	0.44	0	1
0=does not participate		166	74.11				
1=participates		58	25.89				
Inactive	225			0.18	0.38	0	1
0=active		185	82.22				
1=pensioner or unempl.		40	17.78				
Working time	212			0.70	0.46	0	1
0=part time or inactive		63	29.72				
1=Full time		149	70.28				
Vacation house or camping near the Doubs	225			0.08	0.28	0	1
0=no vacation house		206	91.56				
1=vacation house		19	8.44				
Gender	224			0.98	0.15	0	1
0=woman		5	2.23				
1=man		219	97.77				
Dissatisfaction	225			3.62	0.74	0	4
0=indifferent		5	2.22				
1=totally satisfied		0	0				
2=satisfied		4	1.78				
3=dissatisfied		58	25.78				
4=totally dissatisfied		158	70.22				

The median angler is 49 years old and lives in a household of 2 persons. An apprenticeship is the highest education level for a majority of anglers and the average monthly rent is about 1060 CHF. 26% of the respondents participate in an environment protection association (excluding fishing association), 70% work full time and a high majority are men (98%). 18% of anglers are inactive, pensioner for most of them.

8% of the anglers own a vacation house near the Doubs or come to a camping when fishing. In these cases, the travel costs considered is underestimated, since we account only for the distance from the vacation house and not from the permanent address, mostly in the German-speaking part of Switzerland. This also means that 92% of respondents are making the trip from their permanent house to fish in the Doubs.

The dissatisfaction variable asked respondents their opinion of the actual flow management of hydropower plants in the Doubs. The average lies between not satisfied and totally not satisfied. In fact only 4 anglers were totally satisfied and 5 were indifferent. This implies that a high majority of anglers is dissatisfied about the current situation concerning flow in the Doubs.

Statistics of the variables of the model

Table 2 presents first 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.

Table 2: 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

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).

The anglers of the Doubs fished on average 23 times in 2010. However, the median is of 10 visits, suggesting a distribution skewed to the right[22]. This is the case also for the hypothetical number of visits, which is on average 1.92 times higher than for the current situation. Therefore, we already presume that the anglers see a large beneficial effect from flow regulation and thereby water quality improvement.

Table 3 represents the descriptive statistics of the variables used to estimate the model.

Table 3: 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)	502	14.74	10	17.79	0	150
Log Number of visits (actual and hypothetical) ($ln(NV_{id}^k)$)	502	2.12	2.30	1.13	0	5.01
Travel costs (CHF) (P_i)	502	100.63	65.23	131.58	1.68	1183.86
Variables of the model constant across angler						
Travel costs to a substitution site (PS_i)	106	53.93	20.28	78.73	1.52	438.28
Doubs (=1 if fish only in the Doubs) (*Ddoubs*)	106	0.20	0	0.40	0	1
Monthly disposable income (personal or Household, CHF)	106	5433.33	4500	6000.29	204	60000
Weekend (=1 if fish only during weekends) (*Dperiod*)	106	0.24	0	0.43	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 have been excluded because they are not really considered as directly substitutes to the Doubs. Thus, all travels of more than 3.5 hours have been removed. Finally, because 100 anglers did not give

[22] See Appendix 2: histogram of the number of visits

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.

The variable of interest, the travel cost (P_i) , shows an average of 100.63 CHF, which is quite high but mostly affected by a few extreme observations, namely anglers coming from very far away. This can be seen in the travel time and distance variables. Only 7 from the 225 respondents[23] have to travel more than 500 km to the Doubs, with a maximum of 1070 km for an angler coming from Saint-Jean-Pied-de-Port (Pyrénées-Atlantique, France).
Table 4 gives details about all variables necessary to compute the travel costs. The median angler is driving alone to go fishing. The average license price per trip is around 22CHF.

Table 4: descriptive statistics of the travel costs variables

Variable	Obs	Mean	Median	Std dev.	min	max
Travel cost variables						
Distance (number of km to the Doubs)	106	77.41	33.5	132.36	1	1070
Travel time (number of hours to the Doubs)	106	1.31	0.83	1.55	0.25	12.67
Group size (number of anglers in the car)	106	1.71	2	0.79	1	4
Fishing license price[24] (2010, CHF)	106	211.32	145	156.81	17	700
Fishing license price per trip	106	21.94	16	23.95	0.53	145.67

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.

[23] not reported in the table.
[24] For licenses reported in Euro, I took the 2010 average exchange : 1€=1.38CHF.

The variable *Ddoubs* allows to distinguish between people who fish only in the Doubs and the others. 20% of anglers who answered the questionnaire and who has been retained in the regression fish in no other rivers or lakes than the Doubs.

Although asked through an open-ended question, the disposable income (*YD*), was not necessarily reported very accurately by respondents. Moreover, this seems clearly to be the variable of the model that suffers the most from missing values, although it was a totally anonymous survey. The lack of accuracy can come from the fact that, as disposable income was asked, maybe some respondents forgot to deduct taxes. In the same manner, some respondents probably mislead that monthly income was asked and not annual income. High differences in income can also come from other reasons. Since respondents had the choice, personal or household's income was reported which can make a big difference when both adults are working. Moreover, since we have Swiss and French respondents, differences in disposable income can be explained by differences in wages and tax systems. The exchange rate[25] may also add some inaccuracy.

The last control variable of the model, *Dperiod*, is a dummy, indicating here that 24% of the respondents fish only during weekends.

[25] Since the survey is done in June 2011, we assume respondents reported their current income. That is why I took the exchange rate: 1€=1.20CHF.

6. Results

Random effects vs. fixed effects

Before going through the results, I have to choose the best estimation method for the panel data. Hausman test helps to identify whether there is unobserved heterogeneity, that is an invariant unobserved effect for a given fisher, correlated with the explanatory variables. If such unobserved effects are present, then random effects (RE) coefficients are inconsistent and cannot be used to estimate our model. On the other hand, if there is no correlation, as RE assumes, then both fixed (FE) and random effects coefficients are consistent, but FE coefficients are inefficient, so we should use RE. This is basically what the Hausman test verifies. Indeed under the null hypothesis of no correlation between unobserved heterogeneity and explanatory variables, there should be no differences between FE and RE estimators:

Table 5: Hausman test

Variable	Coefficients			
	FE	RE	Difference	S.E.
Travel cost (P_i)	-0.012	-0.002	-0.009	0.002
DHS	0.690	0.773	-0.083	0.014

Test: H_0: difference in coefficients not systematic
Chi^2=22.05
Prob>Chi^2=0.000

Because we can reject H_0 at a 99% level, RE is considered as giving inconsistent coefficients. Thus, if we would have taken the RE this would have yield to inconsistent benefit results, since the travel cost coefficient is the most important estimation in our consumer surplus computation. Indeed, a small coefficient such as -0.002 would lead to extremely high consumer surplus values.

Correlated random effects

The preceding results imply that we have to take fixed effects to get consistent coefficients. However, to control for unobserved heterogenity, which is constant across angler, FE takes the first difference, to remove all fisher-invariant components of the model. This implies that the coefficients of the variables that do not vary across individuals, such as income or substitution travel cost variables, are no longer identified with fixed effects estimation. Thus, since demand not only depends on the price variable, we have to overcome this problem by using the correlated random effects, suggested by Mundlak and Chamberlain, and explained in Wooldridge (2009)[26]. Basically, adding two variables to the model (DHS and P), that is the average by fisher of the variables varying across angler, allows to get the same coefficients as fixed effects (β_P and β_{DHS})[27], without losing information about the angler-invariant variables coefficients.

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

$$\ln\left(NV_i^k\right) = \alpha + \beta_P P_i + \beta_{\bar{P}} \bar{P}_i + \beta_{DHS} DHS_i + \beta_{PS} PS_{il} + \beta_{Ddoubs} Ddoubs_i + \beta_{YD} YD_i + \beta_{Dperiod} Dperiod_i \qquad (12)$$

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

Estimation results

The results of the estimation of equation (12) are provided in table 6. In order to account for zero number of visits and since the logarithm of zero is not defined, I replaced all zero values by 0.1. This could seem ad hoc, but it is useful to know whether the zero observations affect the results[28].

The goodness-of-fit (overall R^2) equals 0.24 meaning that the model explains almost one quarter of the overall variance in number of visits, while the within R^2 indicates that 30% of the within-individual variance is explained by the explanatory 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.

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

[27] The fisher average for the DHS variable should also be added in theory. However, since DHS takes 3 times the value zero and three times the value one for each fisher, 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.

[28] In our case, complete information about anglers not visiting the Doubs are too few to affect consequently the results of the estimation. Several values for 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)

The price coefficient, under a semi-log specification is interpreted as the semi-elasticity of the demand with respect to the price. This means that, ceteris paribus, an increase in travel cost of 10 CHF would 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 (see Appendix 3). Since the price coefficient in the latter case equals -0.907, this means that a 1% increase in the travel costs implies a 0.91% decrease in the number of visits. Prima facie, we could consider that the demand we are estimating is inelastic, since the dependent variable react less than proportionally. However, because the 95% confidence interval ranges the coefficient from -1.15 to -0.67, we cannot conclude on the elasticity as it could be elastic (<-1), unit elastic (-1) or inelastic (>-1).

Table 6: Estimation results
Correlated random effects (semi-log GLS)

Dependent variable: ln(NV) Explanatory variables:	Estimated coefficients:
Travel cost (P_i)	-0.012*** (-6.02)
$\overline{P}_i$	0.010*** (4.76)
DHS (dummy for hypothetical situation)	0.681*** (9.31)
Travel cost to a substitution site (PS_i)	0.002** (2.17)
Ddoubs (dummy for fishing only in the Doubs)	0.463** (2.55)
Dperiod (dummy for fishing only during weekend)	-0.262* (-1.49)
Disposable income (YD_i)	$-4.62e^{-6}$ (-0.29)
Constant	1.843*** (15.08)
Number of observations (2-6 observations per group)	502
Number of groups (anglers)	106
R^2 overall	0.24
R^2 within	0.30

z-stats in parenthesis, *,**,***=significantly different from zero at the 90, 95 and 99% confidence level.

As explained earlier, the correlated random effects estimation gives the same coefficient for price as under fixed effects. The coefficient of the average travel cost by fisher permits to get the RE coefficient of price if we add it up to the travel cost's coefficient. 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 shows that the RE estimators, without considering this correlation, would be biased.

The DHS coefficient is very interesting to look at, since it informs about the magnitude and the effect of a regulation of flow, resulting in an improvement in water quality, on the number of visits. The coefficient is positive and significant at a 99% confidence level and indicates that the shift in the intercept is positive and statistically significant for the hypothetical situation. This implies that an improvement in water quality, as the one presented in the survey, would incite anglers to increase their visit to the Doubs by 68%, ceteris paribus.

As expected by theory, the coefficient of the travel cost to a substitute site has a positive sign, and is significant at 95%. This basically means that the closer an angler lives from a substitute activity, the fewer 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 in other rivers or lakes. The coefficient of the *Dperiod* dummy indicates that people fishing only during weekends and day off are coming less often than the other.

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.

Evaluation of the benefits of an improvement in water quality and flow regulation

Thanks to the results reported in table 6, it is possible to compute the consumer surplus occurring for each individual under the actual and the hypothetical situation. Table 7 provides first a review of the number of visits reported by respondents and predicted by the model.

Since the distribution of the reported number of visits is highly skewed to the right side[29], this implies 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 implies that the increase in the number of visits is less than doubled when taking the mean, while it is tripled with median values.

Table 7: Reported and predicted number of visits

	Reported NV		Predicted NV	
	Mean	Median	Mean	Median
Actual situation (ANV)	22.71	10	15.59	15.05
Hypothetical situation(HNV)	43.53	30	35.43	33.88
ΔNV	+20.82 (+92%)	+20 (+200%)	+19.84 (+127%)	+18.83 (+125%)

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 increase by little less than 20, and is more than doubled, regardless whether we take median or mean. This suggests that predicted mean account less for the several extremely large number of visits than does the average of the reported number of visits.

By dividing the number of visits by the estimated coefficient of price (-0.012), we get the consumer surplus by angler, reported in table 8.

Table 8: Consumer surplus (CS) and benefit estimations by angler per season (CHF)

	Reported NV		Predicted NV	
	Mean	Median	Mean	Median
Actual situation CS	1851	815	1271	1227
Hypothetical situation CS	3548	2445	2888	2761
ΔCS	**+1697 CHF** (+92%)	**+1630 CHF** (+200%)	**+1617 CHF** (+127%)	**+1534** (+125%)

[29] See actual number of visits histogram, appendix 2

The incremental consumer surplus (ΔCS), that is the benefit per angler of improving water quality and flow regulation is quite similar under both reported and predicted number of visits, and under both mean and median, at least in absolute term. However, likewise in table 6, the difference in percentage varies because of the distribution of the number of visits.
We can notice that 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. Bockstael et al. (1990) argue that if error is due to omitted variables, the observed number of visits should be chosen, while the predicted number of visits is better under measurement error. However, Beatty et al. (2005) counter-argue by demonstrating that the error term is unimportant to the determination of expected consumer surplus. Differences occur because censoring of number of visits is not appropriately accounted for. In other words, demands for negative quantities are not observed, leading to a truncation along the price axis. This implies that the average demand curve has a functional form different to that of the individual demands. Although this might be the case here, we can reasonably rely on both results since we are interested in 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 slightly higher than in other studies. For instance Buchli & al. (2002) reported CS=925 CHF 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 founded by Buchli et al. (2002) equals 440 CHF, which is much smaller than my result, although the price coefficient is similar (-0.01). The first distinction we can observe is that although Buchli et al. (2002) also used 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. Indeed, if we use their observed actual number of visits[30] (26) and hypothetical number of visits (36) to compute the consumer surplus, we would find an incremental consumer surplus of 1000 CHF.
Second, and this is the most interesting observation, consumer surplus values are distinct because of the number of visits, suggesting that the situation is different for the two rivers.

[30] Mean taken in the descriptive statistics of the study.

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 in average smaller for the Doubs than for Ticino River[31]. On the other hand, although the hypothetical situation described was the same in both cases[32], 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[33]. As a result, we can mostly explain the high values for the Doubs by its highly critical situation, implying a massive loss of welfare for the anglers[34].

To conclude, table 9 presents the individual consumer surplus in more details, that is, depending on the angler's characteristics, mainly on two variables, that is whether the angler fishes only in the Doubs (*doubs*) and only during weekends (*dperiod*).

Table 9: Per season benefit by angler depending on his/her characteristics* (CHF)

		Dperiod Less intensive angler →		
Ddoubs Less diverse angler ↓		0 (73%)	1 (27%)	Weighted mean
	0 (66%)	H=2763, A=1156 ΔCS=1607	H=1862, A=670.5 ΔCS=1191.5	1495
	1 (34%)	H=4564, A=2201 ΔCS=2363	H=3253, A=1390 ΔCS=1863	2228
	Weighted mean	1864	1420	**1744**

*These are estimations of the consumer surplus according to predicted number of visits depending on the dummy variables. H stands for consumer surplus under hypothetical situation, while A represents the actual consumer surplus. ΔCS is the incremental surplus, in other words the benefit per angler per season for an improvement in water quality and flow regulation.

First we notice that restoring the Doubs will have a much larger impact on the welfare of anglers fishing exclusively in this river. This can easily be understood by the fact that since they do not have a substitute fishing site, an impossibility to fish in the Doubs if the

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[31] This could also be explained by the fact that the average travel cost is higher for the Doubs, that is people are coming from further to fish in the Doubs.

[32] In the questionnaire for the Doubs I presented as an improved situation a flow regulation improved to the hydropower plants. In the Ticino River's questionnaire it was a low-flow alleviation. But the improvement was the same in terms of fishes quantity (250 trout per km). See Appendix 1 for more details about the survey.

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

[34] 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.

situation degenerates would probably force them to completely stop fishing. As a result their loss of welfare in such a situation would be larger than for the other anglers. Thus, at the opposite, an improvement in the situation gives them a larger gain.

Although with less consequent differences, people fishing only during weekends face a lower welfare gain than the others. This comes from the fact that there is little room for them to go more often, even if the situation is improved.

Finally, we saw that the benefits resulting from the predicted number of visits are in general smaller than the one using the reported number of visits (table 8). However, taking the weighted mean (table 9) implies an even a larger benefit than with the reported number of visits, although it is computed with predicted values.

7. Limitations

This chapter presents the different shortcomings of this study. The first subsection presents the multiple purpose trips problematic, a possible remedy to account for it and the results we would get. The second subsection explains other travel cost method issues that have not been addressed in this paper, and should be done in subsequent research.
Second, the sample may suffer from consequent missing values, especially in the income variable. This is why we checked, by a response analysis, whether people not reporting their income would go less often visiting the Doubs. Finally, although not treated here, sample selection, an important problem arising in environmental good valuation survey, is discussed in the last subsection of this chapter.

Multiple-purpose trips

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 they visit their family or enjoy tourism, restaurants, site-seeing, etc. This is problematic since the price they pay to travel to the Doubs should not be totally imputed to value the river. That is, if we do not correct for this, estimates will 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, either I assume that all trips are single-purpose, which is what I did up until now and what can be reasonable for day trip data, or I have to drop the potential multi-purpose trips of the sample. 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[35]." Therefore, table 10 presents the model without individuals driving more than 3.5 hours to reach the Doubs.
The difference is first visible in the significance of the coefficients of *doubs* and *dperiod*, which decreased and *dperiod*'s coefficient is no longer significant. Because of that, the weighted mean computed in table 9 may not be reliable, although it remains interesting in terms of interpretation.

[35] Parsons (2003), p. 277

It is also useful to note that although we dropped almost 20 observations, both overall and within R^2 have increased. Similarly, both price coefficient significance and magnitude have increased. As a result, the benefits are smaller and range from 1449 CHF for the median predicted value to 1513 CHF for the average predicted and observed number of visits[36].

Table 10: Estimation results correcting for multi-purpose trips
Correlated random effects (semi-log GLS)

Variable	Estimated coefficient without correction	Estimated coefficient correcting for potential multi-purpose trips (excluding more than 3.5-hour drive)
Travel cost (P_i)	-0.012*** (-6.02)	-0.014*** (-7.46)
Travel cost average by fisher	0.010*** (4.76)	0.009*** (4.19)
DHS	0.681*** (9.31)	0.657*** (10.27)
Travel cost to a substitution site (PS_i)	0.002** (2.17)	0.003** (2.48)
Ddoubs	0.463** (2.55)	0.322* (1.65)
Dperiod	-0.262* (-1.49)	-0.204 (-1.15)
Disposable income (YD_i)	$-4.62e^{-6}$ (-0.29)	$-6.34e^{-6}$ (-0.52)
Constant	1.843*** (15.08)	2.064*** (14.63)
Number of observations	502	483
Number of groups (anglers)	106	102
R^2 overall	0.24	0.28
R^2 within	0.30	0.37

z-stats in parenthesis, *,**,***=significantly different from zero at the 90, 95 and 99% confidence level.

However, 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 problematic. One solution would have been to ask in the survey whether the anglers have other activities near the Doubs than fishing. Thus, keeping the results of table 8, it is reasonable to assume that the benefit of an improvement in water quality and flow regulation ranges, per angler, from 1450 CHF to 1700 CHF per year.

[36] See appendix 4.

Other limitations of travel cost methods

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 a long distance take fewer but longer trips. If information about number of day per visit would have been available, this would have permitted to compute the consumer surplus per day, that can subsequently differ from consumer surplus per trip, and thus per year.

The second shortcoming of the travel cost method is that the way we computed the price is not the single option possible. There is still highly debate on what to include in costs: should we only account for out of pocket money or also for the opportunity cost of time? In the second case, what is the opportunity cost of time: should it really be computed using wage and if so, for which proportion?

In the same context, we could have computed the travel costs without including license fee. To compare the results, see appendices 5 and 6. Because the semi-elasticity is smaller (-0.01), the consumer surplus is higher and ranges from 1939 CHF to 2032 CHF. However, since I assume that license fee is a relevant expenditure to fish in the Doubs and thus we have to account for it, these numbers will not be retained[37].

The way of defining the substitution site can also be diverse. It depends on the activities we consider as close substitutes. In my case, I just kept the choice of respondents, that is taking all the activities, 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.

Response analysis for missing values in income variable

Since many anglers did not report their income variable, many observations have been lost in the model. In this context it is important to know whether these observations would have significantly affected the results.

[37] Although these results can be used to have a closer comparison with Buchli et al. (2002) results (same price coefficient: -0.01

Therefore, I ran a response analysis, that is a t-test checking whether the number of visits for these people was significantly different. The null hypothesis is rejected, suggesting that including these people would not have affected much the results of the estimation.

However, income variable is not the only variable necessary to estimate the model. We have seen in the descriptive statistics that 100 observations have been excluded because of missing values in one or more explanatory variables. In this context, it is interesting to note that the anglers who answered completely the questionnaire have in average a higher number of visits in the hypothetical situation, than the anglers omitted in the regression[38]. On the other hand, the average reported number of visits under the current situation is similar regardless whether we use the whole sample or the regression sample[39].
This suggest that there is room for selection bias, especially in the hypothetical situation. This concept is further discussed in the following subsection.

Censored observations and sample selection bias

Since it is not possible to have a negative number of visits, observations are so called censored at zero. This could lead in a bias in the estimation of the slope of the demand function. Indeed in our case, if we include the censored observations as NV=0 (NV=0.1 here since we take the logarithm), then the intercept is likely to be underestimated and the slope overestimated. This is the reverse if we exclude the censored observations and just account for NV>0. However, this bias is smaller if the number of zero number of visits is small, as it is in our case[40].
An often used method to overcome this problem is to use a Tobit regression, which provides consistent estimates by using all of the information, including info on censoring. However in my case, since I have only 4 complete observations showing a zero number of visits over the whole sample, it is not useful to use a Tobit model[41].

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[38] Using the whole sample, that is 225 anglers, the average hypothetical number of visits equals 47.07 while it is 43.53 with the regression sample of 106 anglers.
[39] With the sample of 225 anglers, the average actual number of visits equals 22.71 while it is 22.75 with the regression sample of 106 anglers.
[40] On 106 anglers observed in the regression, 4 have NV=0. More precisely, on 497 observations, 5 are left censored, that is 1%. If we include them by replacing NV=0.1, as we did in table 6, the price coefficient equals -0.0123. If we exclude them, the slope is slightly smaller: -0.0122.
[41] Tobit gives a slope between -0.0122 and -0.0123.

More complex models could have been used to estimate the model, accounting for sample selection bias. Sample selection comes from the idea that there exists anyways a bias in the sample since people who answered the questionnaire are in general more interested to the good in question (i.e. the quality of the Doubs) than the whole population in 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[42]. Since the first condition was not verified in our sample, using these models is inappropriate, although sample selection bias probably remain in the results.

Finally, recent with the travel cost method treat the number of visits more widely as a discrete variable than a continuous value as we did here. These are the so called count models, that I already presented in chapter 3, such as Poisson or negative binomial. However, Wieland & Horowitz (2007) argue that lognormal models may have key advantages over count models. 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.[43]" This is exactly what characterizes our sample[44]. However, estimating a negative binomial model or alternative discrete choice models would be the next step in order to check the robustness of our result to different estimation methods.

[42] See for instance the Heckman model used by Buchli et al. (2003).
[43] Wieland & Horowitz (2007), p. 3
[44] See histogram of actual number of visits, appendix 2.

8. Conclusion

This paper aims to evaluate the angler benefit resulting from an improvement in water quality and flow regulation in the Doubs. As many other rivers, the Doubs and its biodiversity is facing with pollution problems from human activity and large flow variations imputed by hydropower plants. This results in a more and more critical threat to the river's biodiversity. In this context, although the situation is complex, one can expect that environmental policies adopted by the French and Swiss authorities should protect such an important natural heritage. To formulate and implement effective policies it is crucial to have an estimation of the economic benefits of restoration. The economic valuation of the recreational use is a helpful approach in order to assess the benefits that would occur if the river would be restored and also to compare the economic value with the costs of restoration.

To assess this benefit, the hypothetical travel cost model 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 quality of the river's flow to its historical level before degradation. A survey has been sent to all the anglers who fished in the Doubs or in other rivers in the region in 2010. I used a semi-logarithmic functional from to explain the number of visits as a function of site characteristics and a binary indicator for the hypothetical restored status. Since each angler reported his/her number of visits to 1-3 sites, the data has been structured as a panel data set. To estimate the travel cost model, I used a correlated random effects model, which is a novelty in the travel cost literature. As opposed to fixed effects model, this model can identify the effects of respondents' characteristics while allowing unbiased estimates of the regression coefficients.
Other alternatives or further extensions of this paper would be to use random utility models with discrete response, to account for heterogeneity between different sites of the Doubs. Similarly, a negative binomial distribution could be used rather than a semi-log functional form to compare the results.

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. At the sample median of 10 visits per year this amounts to one visit out of ten. This permitted to compute the individual consumer surplus occurring in actual and hypothetical situation. Consumer surplus is not confined into one precise number due to limitations in the travel cost methodology, but it provides a range of estimates that may be useful for resource management and allocation as well as policy decisions.

There were approximately 30'400 anglers in the Doubs in 2010 (24'436 anglers in the *Département du Doubs* (FR) and approximately 5000 in the *Département du Jura* (FR), 480 anglers in the *Canton du Jura* (CH), and 500 in the *Canton de Neuchâtel* (CH)). And, according to my estimations, the benefit of the restoration of the water quality and flow regulation ranges, per angler, from 1450 CHF to 1700 CHF per year.
Then, taking the average of the two range limits, the annual benefit of the restoration of the river is approximated to 48 Mio CHF. This benefit is expressed in terms of welfare gain for the anglers and not necessarily translated into monetary exchanges. These are rather 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 the way of computing the consumer surplus. Also, the number of anglers in the Doubs is very large. Lastly, the rest of the difference can be imputed to the critical situation of the Doubs, implying large losses of welfare for concerned individuals, such as the anglers.

Besides sample selection bias and the problem of multi-purpose trips, the hypothetical travel cost method could be subject to another potential bias due to strategic behavior. This would assume that anglers deliberately overstated their number of visits under the improved situation, in order to increase the apparent benefits. However, compared to other methods such as contingent valuation method, we could expect that strategic behavior is less likely to happen since the willingness to pay is not directly asked.
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, hence might underestimate recreational benefits of improvements. 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 and climatic impacts, as well as human health implications. For instance, the river is a source of drinking water for several French villages.
However, an ex ante appraisal of a relatively well-defined part of these benefits may still be useful for policy makers to enable them to make preliminary comparisons with the entailed costs.

To conclude, 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 (approximately 48 Mio CHF per year) are sufficiently large to suggest that at least a few rapid actions would be easily offset by the benefits. Of course, one should also keep in mind that such policies would imply a cost for the entire population through taxes, while the benefits considered here are only for anglers. However, as we already mentioned it, anglers are not the only beneficiaries of a restoration.
It is also important to note that rivers such as the Doubs are exploited to generate cheap and occasionally subsidized goods such as "green" electricity. The results of this study suggest that such productions could induce considerable externalities that deserve attention.

Finally, given the complexity of the situation, is a complete restoration utopian? This question is relevant from the point of view that we might have already reached a no-return point in the river's degradation. To what extent the biodiversity can be recovered is a question that requires further biological research. In any case, if the situation further deteriorates, this paper suggests that the loss of welfare would increase. As a result, even preserving the actual situation is a source of a great economic value. In fact, even in the actual degraded situation, the consumer surplus of the median angler is estimated at 815 CHF per year. Thus, the value of the Doubs in 2010, that is the benefit of preserving it at its actual situation, is about 25 Mio CHF per year form the anglers' point of view.

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10. Appendix

Appendix 1: Survey

QUESTIONNAIRE SUR
LA VALEUR DU DOUBS ET DE SA FAUNE POUR LES PÊCHEURS

Partie 1: Questions concernant vos habitudes dans la pratique de la pêche.

Dans cette partie du questionnaire, je souhaiterais vous poser quelques questions concernant vos habitudes dans la pratique de la pêche et votre évaluation de la situation actuelle concernant les niveaux d'écoulements dans le Doubs.
(Attention, le questionnaire porte sur votre pratique de pêche durant la saison 2010)

1 Où vous rendez-vous pour pêcher? (cochez une ou plusieurs réponses)

Dans **le Doubs** ☐(1) Dans **les lacs et les étangs** ☐(3)
Dans **d'autres rivières** ☐(2)

2 Normalement, quel jour de la semaine allez-vous pêcher?

(cochez une ou les 2 réponses)
Les jours ouvrables ☐(1)
Le week end et les jours fériés ☐(2)

3 Faites-vous partie d'une association de protection de la nature (à l'exception de l'association de pêche)?

oui ☐(1) non ☐(2)

4 D'où partez-vous habituellement pour aller pêcher?

No de code Postal: ______________________
Lieu (ville, village) de départ: ______________________

5 En moyenne, pour une seule pêche, combien de temps consacrez-vous (temps de trajet aller-retour + temps de préparation + durée moyenne de la pêche)?

Nombre approximatif d'heures: ______________________

6 En moyenne, par année, combien dépensez-vous en matériel de pêche?

Prix approximatif (indiquez si CHF ou €): ______________________

7 Quel type de pêche pratiquez-vous? (cochez une ou plusieurs réponses)

☐(1) Je pratique la pêche à la mouche
☐(2) Je pratique la pêche au toc
☐(3) Je pratique la pêche au lancer
☐(4) Autre: ______________________

8 Êtes-vous satisfait de l'écoulement des flots actuels dans le Doubs?

☐(1) très satisfait ☐(2) satisfait
☐(3) insatisfait ☐(4) complètement insatisfait
☐(5) je suis indifférent aux problèmes concernant le débit de l'eau dans le Doubs

Partie 2: Evaluation d'un changement du débit de l'eau dans le Doubs

Les pêcheurs ont longtemps soutenu la nécessité de **réguler l'écoulement des flots dans le Doubs**. En effet, comme on peut le voir sur les photos ci-dessous, il arrive souvent que le débit de l'eau fluctue beaucoup en très peu de temps, provoquant la régression voire la disparition de nombreuses espèces animales.

Une éclusée sur le Secteur du refrain. 20 minutes séparent ces deux photos:

Photos: Patrice Malavaux

Imaginons maintenant que l'écoulement des flots soit totalement régulé dans le Doubs, de sorte que de tels changements de débit ne puissent plus avoir lieu. Supposons alors, de manière purement hypothétique, que cela entraîne une amélioration sensible de l'abondance de poissons (soit une **augmentation d'environ 250 truites par km** de rivière). Vu l'amélioration, toutes les interdictions seraient levées et l'abondance des truites serait uniforme dans tous les tronçons du Doubs. Faisons l'hypothèse qu'il n'y ait pas d'étiage non plus.

Nous aimerions maintenant savoir comment vous modifieriez votre comportement si cette amélioration devait vraiment avoir lieu. Même si cette amélioration vous semble impossible en réalité, il est très important pour l'étude que vous imaginiez la situation et que vous répondiez sérieusement aux questions suivantes. Il s'agit de savoir si, grâce à l'augmentation de l'abondance de truites, vous iriez plus souvent pêcher au Doubs que dans la situation actuelle.

9 Si cette amélioration devait vraiment avoir lieu, veuillez indiquer, concernant les 3 endroits du Doubs où vous iriez pêcher:

	Village le plus proche du secteur du Doubs où vous iriez pêcher après la régulation de l'écoulement	Le nombre de sorties par année dans chaque endroit, compte tenu de l'augmentation du nombre de truites
1)	______________	______________
2)	______________	______________
3)	______________	______________

10 **a)** La régulation de l'écoulement des flots améliore les conditions de pêche, mais entraîne des pertes en terme de quantité d'électricité produite. En effet, si les barrages étaient régulés, il faudrait compenser les pertes en achetant d'autres sources d'électricité. Imaginons qu'il faille dans ce cas augmenter la taxe d'électricité annuelle pour améliorer le débit de l'eau dans le Doubs.

Pouvez-vous indiquer ce que vous seriez prêt à verser (montant <u>maximal</u>) en plus <u>par année</u> pour une régulation de l'écoulement des flots?

0 Frs.	(0€)	☐	60 Frs.	(49€)	☐
10 Frs.	(8€)	☐	70 Frs.	(57€)	☐
20 Frs.	(16€)	☐	80 Frs.	(66€)	☐
30 Frs.	(25€)	☐	100 Frs.	(82€)	☐
40 Frs.	(33€)	☐	150 Frs.	(66€)	☐
50 Frs.	(41€)	☐	200 Frs.	(164€)	☐

Montant autre ou supérieur (Indiquez si Frs. ou €):____________________

b) Si la réponse au point a) est 0 Frs., pouvez-vous indiquer la raison?

☐ (1) Je ne suis pas intéressé par une régulation de l'écoulement des flots
☐ (2) Je préfère dépenser mon argent pour autre chose
☐ (3) Je n'ai pas les moyens de payer pour cela
☐ (4) Ce n'est pas à moi de payer pour cela
☐ (5) Autre raison: ________________________________

Partie 3: Questions aux pêcheurs du Doubs de 2010

Si vous avez pêché dans le Doubs durant la saison de pêche 2010, je souhaiterais connaître votre pratique durant cette saison. Si ce n'est pas le cas, passez directement à la partie 4.

11 **Durant la saison de pêche <u>2010</u>, combien de fois environ êtes-vous allé pêcher dans le Doubs?** (si autre réponse, merci d'indiquer combien sur la ligne)

Tous les jours	☐ (1)	2 fois par mois	☐ (4)
3-4 fois par semaine	☐ (2)	1 fois par mois	☐ (5)
1-2 fois par semaine	☐ (3)	3-4 fois par année	☐ (6)
Autre réponse	☐ (7)	______________________________	

12 **Où avez-vous obtenu votre permis de pêche pour le Doubs en 2010? (cochez une ou plusieurs réponses)**

☐ (1) AAPPMA la frontalière
☐ (2) Service de la faune neuchâtelois
☐ (3) AAPPMA Villers-le-Lac
☐ (4) Office de l'environnement jurassien
☐ (5) AAPPMA Grand combe des Bois
☐ (6) AAPPMA La Franco-Suisse
☐ (7) Autre:______________________

13 **En 2010, combien vous a coûté votre permis de pêche pour le Doubs?**
Prix (indiquez si CHF ou €):______________________________

14 a) Remplissez le tableau ci-dessous en référence aux trois endroits du Doubs où vous pêchez le plus souvent (saison 2010), en indiquant:

	Village le plus proche du secteur du Doubs où vous pêchez	Distance approximative (en km) du lieu de départ au lieu de pêche (seulement l'aller)	Le nombre de fois où vous êtes allé pêcher dans ces trois endroits durant la saison 2010	Le moyen de transport utilisé habituellement pour aller à la pêche
1)	______	______	______	______
2)	______	______	______	______
3)	______	______	______	______

b) Si vous utilisez la voiture, combien de pêcheurs viennent habituellement avec vous?

Nombre de personnes (vous exclu): ______________

15 En cas d'impossibilité de pouvoir pêcher dans le Doubs (par ex, pour cause de sécheresse), quelle alternative choisiriez-vous?
(Cochez une ou plusieurs réponses)

		Pouvez vous indiquer où ? (Village le plus proche ou Pays)
Pêche dans d'autres rivières de la même région	☐ (1)	______
Pêche dans un lac/étang	☐ (2)	______
Pêche dans des rivières d'autre régions de Suisse ou à l'étranger	☐ (3)	______
Je choisirais une autre activité de plein air	☐ (4)	______
Aucune de ces propositions	☐ (5)	
Autre: ______________	☐ (6)	______

Partie 4: Informations socio-économiques

Pour une évaluation économique correcte du Doubs et de sa faune, il est important de connaître quelques données socio-économiques vous concernant. **Vos réponses seront bien entendu traitées de manière totalement confidentielle et anonyme.**

16 Votre année de naissance: 19 ______

17 Sexe: femme ☐ (1) homme ☐ (2)

18 Lieu de domicile fixe:
Code postal: ______________
Ville, village: ______________

19 Combien de personnes vivent dans votre ménage, vous inclus?
____

20 Quel est le niveau de formation le plus haut que vous avez atteint:

Ecole obligatoire ☐ (1)
Formation professionelle (p.ex. apprentissage) ☐ (2)
Ecole de commerce/Ecole normale/Maturité ☐ (3)
Haute école/Université ☐ (4)

21 Quelle est votre activité professionnelle?

a) Secteur d'occupation:

Agriculture ☐ (1)
Industrie ☐ (2)
Artisanat ☐ (3)
Commerce ☐ (4)
Services ☐ (5)
Secteur public ☐ (6)
inactif ☐ (7)
Autre ☐ (8)_______________

b) Position professionnelle:

Travailleur autonome ☐ (1)
Employé ☐ (2)
Profession libérale ☐ (3)
Entrepreneur ☐ (4)
Etudiant ☐ (5)
A la retraite ☐ (6)
Au chômage ☐ (7)
Autre ☐ (8)_______________

c) Travaillez-vous à temps plein? oui ☐ (1) non ☐ (2)

22 Lorsque vous avez annoncé le montant de votre contribution annuelle pour la régulation de l'écoulement des flots (question 10) **à quel revenu avez-vous pensé?** (veuillez indiquer le salaire net mensuel en question et si € ou Frs)

☐ (1) Au revenu de l'ensemble du ménage, c'est à dire environ ____________ net par mois

☐ (2) A mon revenu personnel, c'est à dire environ _____________ net par mois

23 a) Si vous utilisez votre propre voiture pour aller pêcher, à combien s'élève environ le coût de l'essence par mois pour la pêche?

Dépense approximative (indiquez si € ou Frs.)____________________

b) Si vous utilisez les transports publics, ou si vous louez une voiture, à combien s'élève le coût de transport pour aller pêcher par mois?

Dépense approximative (indiquez si € ou Frs.)____________________

24 Quel est le montant de votre loyer ou hypothèque par mois?
Loyer approximative (indiquez si € ou Frs.)____________________

Merci pour votre précieuse collaboration!
Pour toutes questions ou remarques, contactez:

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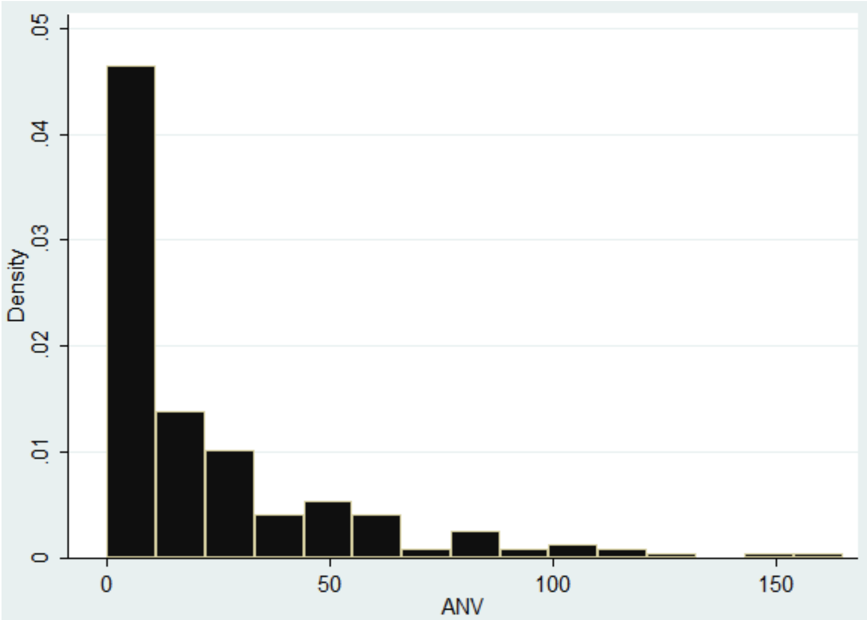
Appendix 2: Histogram of the number of visits in 2010 in the sample

Figure 4: Histogram of the actual number of visits



Appendix 3: Estimation results using a log-log specification

Table 11: Estimation results
Correlated random effects (log-log GLS)

Dependent variable: ln(NV)	
Explanatory variables:	Estimated coefficients:
Log of travel cost (lnP_i)	-0.907*** (-7.46)
$\overline{\ln P_i}$	0.651*** (4.41)
DHS (dummy for hypothetical situation)	0.696*** (9.88)
Log of travel cost to a substitution site (lnPS_i)	0.110** (2.04)
Ddoubs (dummy for fishing only in the Doubs)	0.298 (1.56)
Dperiod (dummy for fishing only during weekend)	-0.233 (-1.27)
Log of disposable income (lnYD_i)	-0.116 (1.17)
Constant	1.476* (1.67)
Number of observations (2-6 observations per group)	502
Number of groups (anglers)	106
R^2 overall	0.24
R^2 within	0.33

z-stats in parenthesis, *,**,***=significantly different from zero at the 90, 95 and 99% confidence level.

Appendix 4: Consumer surplus estimations correcting for multi-purpose trips

Table 12: Consumer surplus (CS) and benefit estimations by angler per season (CHF), corrected for multi-purpose trips

	Reported NV		Predicted NV	
	Mean	Median	Mean	Median
Actual situation CS	1650	727	1259	1190
Hypothetical situation CS	3163	2180	2772	2639
ΔCS=benefit	**+1513 CHF** (+92%)	**+1453 CHF** (+200%)	**+1513 CHF** (+120%)	**+1449** (+122%)

Appendix 5: Estimation results using travel costs excluding license fee and corrected for multi-purpose trips

Table 13: Estimation results excluding license fee in travel costs computation
Correlated random effects (semi-log GLS)

Dependent variable: ln(NV) Explanatory variables:	Estimated coefficients (excluding observations with more than a 3.5-hour drive)
Travel cost (P_i)	-0.010*** (-3.89)
$\overline{P}_i$	0.006** (2.06)
DHS (dummy for hypothetical situation)	0.841*** (12.66)
Travel cost to a substitution site (PS_i)	0.003** (2.13)
Ddoubs (dummy for fishing only in the Doubs)	0.119 (0.63)
Dperiod (dummy for fishing only during weekend)	-0.287 (-1.57)
Disposable income (YD_i)	$-4.31e^{-6}$ (-0.33)
Constant	1.899*** (13.68)
Number of observations (2-6 observations per group)	511
Number of groups (anglers)	111
R^2 overall	0.20
R^2 within	0.31

z-stats in parenthesis, *,**,***=significantly different from zero at the 90, 95 and 99% confidence level.

Appendix 6: Benefit estimation using travel costs excluding license fee and corrected for multi-purpose trips

Table 14: Consumer surplus (CS) and benefit estimations by angler per season (CHF), TC excluding license fee and corrected for multi-purpose trips

	Reported NV		Predicted NV	
	Mean	Median	Mean	Median
Actual situation CS	2202	969	1426	1478
Hypothetical situation CS	4220	2908	3458	3485
ΔCS=benefit	**+2018 CHF** (+92%)	**+1939 CHF** (+200%)	**+2032 CHF** (+143%)	**+2007 CHF** (+136%)