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► **To cite this version:**

Anna Créti, Federico Pontoni. Cheaper electricity or a better river? Estimating fluvial ecosystem value in Southern France. 2014. hal-00998614

HAL Id: hal-00998614

<https://hal.science/hal-00998614>

Preprint submitted on 2 Jun 2014

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ÉCOLE POLYTECHNIQUE

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE



CHEAPER ELECTRICITY OR A BETTER RIVER?
ESTIMATING FLUVIAL ECOSYSTEM VALUE IN
SOUTHERN FRANCE

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May 2014

Cahier n° 2014-15

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Cheaper electricity or a better river? Estimating fluvial ecosystem value in Southern France

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May 2014

Abstract

In the next years, France will renew a consistent share of hydroelectric concessions, among which we find those insisting on the Aspe and its tributaries (for a total of almost 100 MW). Beauty contests will take place, where bidders will present offers for technical and environmental improvements, as well as a revenue sharing percentage for Local Authorities. This framework generates a potential trade-off between revenue-sharing and environmental improvement. Our work investigates this trade-off by means of a discrete choice experiment (DCE) to estimate people's preferences. The experiment has been conducted on a representative sample living in the Aspe valley. In our DCE, we translate the revenue sharing in an immediate rebate in the electricity bill. Respondents could choose higher rebates and lower ecosystem improvements or lower (or no) rebate and higher ecosystem amelioration.

According to the experiment results, the highest total willingness to pay (WTP) is above € 144 per household and per year. Moreover, people's marginal WTP for a satisfactory fish stock reaches 250 €/year, that is three times the maximum rebate that was offered. Finally, all environmental attributes are considered as significant and worth a monetary effort. Therefore, hydroelectric concession bidders should give clear priority to environmental aspects.

JEL Classification: H23, Q2, Q4, Q5

Keywords: Water Framework Directive, Choice Experiment, Hydropower.

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1 Introduction

In the next years, France will have to renew a consistent share of hydroelectric concessions, among which we can find those insisting on the Aspe and its tributaries (for a total of almost 100 MW of installed capacity). The Aspe is the torrential river flowing through the Aspe valley, one of the three main valleys of the High-Béarn, in the Southwest of France. The Aspe river is part of Natura 2000, an ecological network of protected areas within the European Union.

In 2008, the EU forced the French Government to adopt a transparent and non-discriminatory procedure to renew hydro concessions. Accordingly, France modified the procedure pursuant to which concessions of hydroelectric plants with an installed capacity of more than 4.5 MW are awarded to private operators. Whereas, under the former procedure, the incumbent had a preference right when concessions expired, the new provision introduces publicity and competition requirements in the selection process. Within the tender procedure the environmental aspects will weigh significantly as, in compliance with the Water Framework Directive (WFD, 2000/60/EC), France rivers are expected to attain a good ecological status by 2015.

The procedure introduced by the French Government is structured as a beauty contest, where petitioners have to fulfill different criteria determined by the French Ministry of energy and Environment (MEEDDM), and namely:

1. Technical improvements: which means that candidates are expected to significantly ameliorate the existing infrastructures in order to increase (if possible) the production;
2. Environmental impact: within each project, petitioners have to show their actions to reduce their environmental impact;
3. Revenue sharing: candidates are expected to present a financial business plan in which they will show the expected revenues and a revenue sharing percentage (which will then be divided among the State and Local Authorities).

Despite being an emission free technology, hydropower impacts the environment in several other ways. In particular, hydropower production harms biodiversity, fluvial ecosystems and their services (among others: Céréghino *et al.*, 2002; Croze *et al.*, 2008; Brown *et al.*, 2009; Renofalt *et al.*, 2010).

Impacts vary greatly according to the (non) adoption of mitigation measures and to production strategies. Mitigation measures vary from simple fish-passages to complex outflow reservoirs aimed at minimizing flow changes generated by hydro-peaking. Changes in production strategies normally mean reducing flow alterations by means of re-naturalisation (Nilsson,

1996). This is in sharp contrast with the functioning of electricity markets, as intraday price volatility clearly implicates intraday production variability.

For instance, the impact of different mitigation and management choices on fish migration has been tested by Chanseau *et al.* (1999) on one hydropower scheme on the Aspe river. The authors conducted two experiments, the first one in 1995 and the second one in 1998, to test the efficiency of two different downstream bypasses for salmon smolts. In 1995, the bypass efficiency was very low (with a success rate of 17%), mainly due to hydraulic conditions. A training wall was built in 1997 to reverse the flow pattern in the canal and to better guide the fish to the water intake of the new bypass. This simple change improved the bypass efficiency to 55%. Moreover, the authors demonstrated that efficiency of both devices and the smolt behavior were directly affected by the turbine operation and the hydraulic conditions in the intake channel.

As specified above, the renewal procedure introduced by the French Government is structured as a beauty contest, where petitioners (bidders) have to offer a revenue sharing percentage and to propose environmental improvements. We expect that the higher the offer for environmental improvements, the lower the offer for revenue sharing.

The scope of this paper is straightforward: we study the emerging trade-off between a better environment and a higher percentage of money handed down to Local Authorities by estimating people's preferences. Therefore, we have conceived a discrete choice experiment (DCE), whereby we translate the revenue sharing in an immediate rebate in the electricity bill. Respondents could opt for a higher rebate, with the consequence that the fluvial ecosystem remains at its current status (that is, operators cannot perform worse than the incumbent from an environmental point of view), or for a lower (or even no) rebate for (substantial) fluvial ecosystem improvements.

In real life, there will be no rebate; still, an increased amount of money for local communities should mean either less local taxes or better local services. This justifies also why we targeted only people leaving in the Region and not people from anywhere in France: a consistent part of the revenue sharing percentage will, in fact, accrue to local authorities.

The paper shows that people are willing to pay to increase the ecological status of the Aspe river; the highest total willingness to pay (WTP) is above € 144 per household and per year.

The paper unfolds as follows: in section 2 we review the literature on aquatic ecosystem evaluation; section 3 sets out the experimental design and the econometric approach; section 4 is devoted to the results of the choice experiment; section 5 concludes.

2 Literature review on aquatic ecosystem evaluation

There are several techniques to monetize environmental impacts. It is beyond the scope of this paper to discuss the pros and cons of each methodology (for a critical assessment see Bateman et al., 2002). Given the multidimensional and complex nature of ecosystems, there is ample scientific consensus (Hoyos, 2010) that the method most capable of estimating how a combination of changes to one or more ecosystem services affects human welfare is the discrete choice experiment.

DCE involves the design of a hypothetical market, in which people have to choose their preferred “product”, which is decomposed in some relevant attributes, each of which has more than one level. For instance, the product car, can be decomposed in two attributes, one being Origin of the producer and the other one being Design. Each attribute can take several levels; for instance, the first attribute can have three levels (Italian, German, Other European), while Design might have just two (Coupé and Station Wagon). Respondents face several choice sets, each containing a certain number of mutually exclusive alternatives, relating the potential product to a change of in the level of its attributes. Clearly, each alternative has a price: consequently, respondents will choose according to their taste, but also according to the price of the product. Repeating the choice with different combinations of levels and prices should return the attribute level that is valued the most.

When it comes to environmental goods, and in particular the fluvial ecosystem, it is important to relate the change of attribute levels to an action, normally a change in policy or a change in managing the resource or other choices that have an impact on it. A standard procedure when testing DCE for environmental goods is to include in every choice set an alternative that reflects either the current status (status quo) of the good being evaluated or an opt-out alternative, which means the worst possible situation. Normally, the price (or cost) of these alternatives is equal to 0. The DCE format allows marginal utility estimates for changes in the level of each attribute to be easily converted to WTP estimates. Moreover, given that compensating variation measures may be obtained, it is possible to estimate the total value of improvements to the environmental good as a consequence of the policy or managerial change.

Whenever evaluating the environmental impacts in water bodies, the crucial elements for the design of DCE are: the definition of the affected population; the delimitation of the water bodies under analysis, and the attributes chosen to describe the environment.

As for population scale, it can vary from just the users or those residing near the water bodies under study (Hynes et al., 2008; Kataria et al., 2012; Stithou et al., 2012) to a representative sample of the regional or national population (Kataria, 2009; Metcalfe et al., 2012). The target

population clearly depends, on the one hand, on the expected effects of the policy or managerial changes under consideration, on the other, on the water bodies under consideration, which can vary from a single river (Hanley et al., 2006), to a river catchment (Brouwer et al., 2010; Poirier and Fleuret, 2010), to all the water bodies in a region or country (Kataria, 2009; Metcalfe et al., 2012).

Normally, attributes used in the DCE surveys relate the ecology of the water body to recreational opportunities and to the aesthetics of the water body. It is important to bear in mind that the attributes chosen for the choice experiment should differ from the attributes studied for determining the environmental impacts. Why so? In order to have a successful choice experiment, there is the need to test attributes that are relevant for the stakeholders involved, which normally means the general public. Consequently, the attributes or the levels used in the questionnaires have to be linked to the environmental attributes used to assess the impacts, but they need not to be the same. A simple example might help: an attribute such as water quality can be expressed in terms of its different levels of chemical components or in simpler terms such as swimmable or non-swimmable; it is straightforward that this familiar attribute to the general public depends on the level of some chemical substances. This means that attribute levels are commonly qualitative (Hanley et al., 2005; Alvarez-Farizo et al., 2007; Birol et al., 2008) and sometimes with images or visual descriptions (Doerthy et al., 2013). The most common attributes are: biodiversity levels, generally described as different quantities of native species (Morrison and Bennett, 2004; Kragt et al., 2011); recreational activities, that is the possibility to practice them or not (Doerthy et al., 2013); and aesthetics often described as a conglomerate of the effects of litter, smell and clarity (Alvarez-Farizo et al., 2007), sewage (Hanley et al., 2006) and pollution (Stithou et al., 2012).

To our knowledge, only one paper has used DCE to estimate how individuals value different environmental improvements for rivers where hydropower production takes place, that is Kataria (2009). The paper focuses on Swedish rivers and its aim is to assess the market share of environmentally friendly producers, which are expected to face higher production costs.

The peculiarity of the DCE we have conducted is the bidding vehicle that we have used. Instead of an electricity bill increase, the vehicle is a bill rebate, which is normally associated with a willingness to accept. How is it possible to design a rebate as a willingness to pay?

Within the renewal procedure, bidders are asked to offer a percentage of revenue sharing and an improvement of the fluvial ecosystem. First of all, this means that the opt-out alternative is the current status. Secondly, this means that whoever wins will either pay to Central and Local Authorities the current revenue sharing percentage (which is 0%) or, more probably, a higher

one. Consequently, bidders will present offers which mix different levels of environmental improvement and revenue sharing percentages. Both strategies have minimum thresholds: from an ecosystem point of view, they cannot be below the current status; as for the percentage, it cannot clearly be below 0%.

Since improving fluvial ecosystem is costly, we expect that higher levels of ecosystem recovery be associated with lower economic offers; conversely, higher economic offers will come at the price of lower levels of ecosystem recovery. Whenever a trade-off emerges, it is important to test people's preferences. In order to do so, it is fundamental to find a good way of presenting the situation. In this case, we have imagined that this revenue sharing percentage can be translated into immediate rebates in the electricity bill. Actually, there will be no rebate; still, an increased amount of money for Local Authorities should mean either less local taxes or better local services. In this case, though, rebates are not associated to ecosystem degradation: in fact, at the highest level of rebate is associated the status quo. As a consequence, the experiment has a willingness to pay approach: we are asking people whether they are ready to renounce to money they could spend on something else in order to have a better fluvial ecosystem.

Whenever evaluating the environmental impacts in water bodies, the crucial elements for the design of DCE are: the definition of the affected population; the delimitation of the water bodies under analysis and the attributes chosen to describe the environment (see the previous chapter for details). Given that Local Authorities will benefit from the renewal procedure, we decided to target only people living in the Region and not people from anywhere in France.

3 Experimental design

3.1 The Aspe river

The Aspe is the torrential river flowing through the Aspe valley, one of the three main valleys of the High-Béarn, in the Southwest of France. The Aspe river is part of Natura 2000, an ecological network of protected areas within the European Union. On the Aspe river there are 16 hydropower plants, for a total of 93 MW, of which 63 MW are run-of-the-river plants.

In 2007, a road accident in the Aspe Valley resulted in the discharge of 17,000 litres of Potassium Hydroxide in the river, destroying the entire fauna for 4 kilometres and severely affecting the upper part of the river. This led to an immediate ban on fishing for 5 years and to the adoption of restoration measures. After seven years, the Aspe ecosystem has recovered, but the accident has increased environmental awareness in the local population. Moreover, it has shown how important is the natural flow: all hydropower operators were forced to release water in order to dilute the Potassium Hydroxide, letting the river act as a natural depurator.

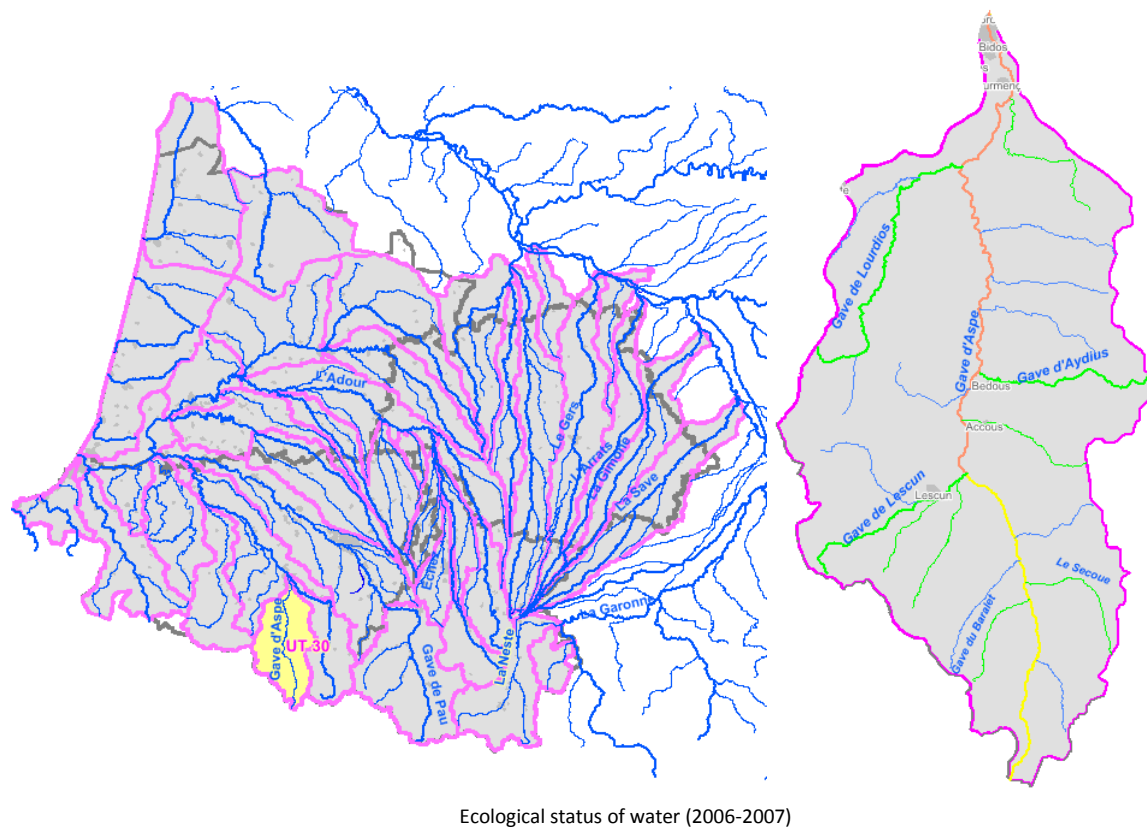


Figure 1: Localization of the Aspe river and its ecological status

Four years after the road accident, the French Ministry of Environment conducted an economic analysis of the events (Application des methods d'équivalence à la pollution accidentelle du Gave d'Aspe, 2011), based solely on restoration costs. In the final document, the Ministry acknowledged the need to compare the results with other methods and, in particular, with stated or revealed preferences. Unfortunately, these analyses were never carried out. At the end of our study, we will compare our findings with the figures in the abovementioned document.

3.2 Structure, attributes and levels

The questionnaire consisted of two parts. In the first part respondents were asked questions about their attitude towards the Aspe river and their socio-economic status. The second part, instead, contained the choice experiment.

Attributes and levels relevant for the Aspe river ecosystem have been chosen with a Delphi survey, which involved 15 selected experts and which was coordinated by the local Water Agency (Agence de l'eau Adour-Garonne). The Delphi survey was crucial not only to define the

attributes and their levels, but it also confirmed that different way of managing hydropower production were effective in increasing the quality of the riverine ecosystem. The results of the Delphi showed that there are three attributes that are more relevant for the Aspe ecosystem, namely *water quality*, *fish population* and *hydro-morphology*. Moreover, with the Delphi it was possible to define the present situation of the three attributes describing the fluvial ecosystem. For the sake of understanding, all attribute levels have been expressed in qualitative and figurative terms. Finally, experts provided me with images and visual descriptions of the attributes described.

As stated above, the first attribute is *water quality*, representing the chemical and physical conditions of the waters. The attribute is represented qualitatively, according to the scale provided by the Water Agency. The present situation is sufficient, while the foreseen improvements are good and very good.

The second attribute is *fish population*. Hydropower production normally has a consistent negative impact on the natural reproduction of fish population (Renofalt *et al.* 2010). The Aspe River is one of the last rivers in the Pyrenees where the Atlantic salmon and the sea trout migrate for reproduction (DRE, 2008). The protection of these species is crucial and those fishes are essential elements of the Aspe ecosystem. The levels chosen were qualitative and based on the scale defined by DRE, 2008. The actual status is unsatisfactory.

The third attribute is *hydro-morphology*, which indicates whether a river has a natural flow. The attribute was represented with images taken from the Aspe river. We used this attribute to see how much the respondents value a naturally flowing water body. In fact, if properly designed, built and managed hydropower plants might not alter significantly the natural flow of the river, which in turn increases the riverine ecosystem. The actual status is artificial. In Table 1, we show that two attributes have two levels, while *water quality* has three.

Attribute	Description	Level
Water Quality	Chemical conditions	Sufficient; Good; Very Good.
Fish Population	Abundance and evolution of the stock	Unsatisfactory; Satisfactory.
Hydro-morphology	Closeness to natural conditions	Natural; Artificial.
Rebate	Reduction of electricity bill per household (in EUR)	0; 10; 45; 75.

Table 1: Attribute and attribute levels.

The maximum rebate was determined taking into account how much could accrue to a single household. At present, the only Concession where the revenue-sharing mechanism has taken place is the one on the Rhone, held by CNR. The revenue sharing has been set at 25% (CNR,

2013), a percentage that we have used for our computation. The maximum rebate could not exceed 75 euro per household, corresponding to a considerable 15% of the average electricity bill (CRE, 2013), considering that:

- the average electricity price on the Power Exchange for 2013 was around 50 €/MWh (CRE, 2013);
- according to the French law 75% of that 25% goes to the Local Authorities (Code de l’Energie);
- in the Aspe Region there are approximately 11,500 households (INSEE, 2013), of which 1,200 live in the area where the accident took place.

Each choice set contained three alternatives, inclusive the status quo alternative, which was included in all of the choice sets. Of course, we deleted strictly dominating choice sets. The final design contained eight choice sets.

We labeled each alternative as “electricity supplier x ” (with x ranging from 1 to 3), following Kataria (2009). This means that, for the sake of the choice experiment, suppliers differed from each other for their remedial measures; that is, for the level of the environmental attributes attained. As a consequence, respondents faced a choice where they could choose the preferred method for producing hydropower.

3.3 Econometric model

We used the standard random utility model developed by McFadden (1973) to study respondents’ choices. RUM is a standard practice within DCE data analysis as its basic assumption is that the utility for an individual is composed of an observable component and a random component, which gives a utility function of this form:

Equation 1

$$U_{ni} = V_{ni} + \varepsilon_{ni} = \beta x_{ni} + \varepsilon_{ni}$$

where V_{ni} represents the observable component, ε_{ni} the random component, x_{ni} represents a vector of attributes used to describe alternative j , and β a vector of parameter coefficients to describe preferences for the x attributes.

DCE analysis normally starts with a conditional logit (CL) model. Under the CL model, the choice probability for individual n can be represented as follows:

Equation 2

$$Prob_{ni} = \frac{\exp(\beta x_{ni})}{\sum_j \exp(\beta x_{nj})}$$

CL model, though, has some restrictive assumptions. For instance, the model is underpinned by the “independence and identical distribution” condition of the error terms. Consequently, it is now commonplace to compare CL results with more flexible specifications, for instance the random parameters logit (RPL) model. In the RPL model, the parameters vary over decision-makers in the population with density $f(\beta)$. Therefore, the unconditional choice probability represents the integral of the logit probabilities over all possible values of β_n . As a result, the choice probability can be represented by a product of logits.

Equation 3

$$Prob_{yn} = \int \prod_{t=1}^T \frac{\exp(\beta x_{ni})}{\sum_j \exp(\beta x_{nj})} f(\beta) d\beta$$

where T is the number of choices observed for each respondent and represents the fact that the model is estimated to account for the panel nature of the data. We have decided to model the distribution of the heterogeneity in the non-cost random coefficients with a Normal distribution. Finally, both models have been further specified to enable observed factors to enter as explanatory variables. The distribution of the parameters in the RPL model is simulated using 400 Halton draws.

4 Results

The choice experiment has been addressed to a representative sample of 200 households in the Aspe Region (obtaining a 100% of valid responses).

Variable	Mean
Age	41.2
Household component	2.2
Female	0.6
Retired/inactive	0.42
Knowledge of concession renewal	0.16
Membership in an environmental organization	0.02

Table 2: Descriptive statistics.

The mean age of the respondents is 41.2 years and household components are just above 2. Almost half of the sample is made of retired or inactive people. All these data are precisely in line with the descriptive statistics from the INSEE and confirm that we have a representative sample. The respondents were not previously informed of the relevant characteristics of hydropower production, in order not to influence their choices. Still, the questionnaire contained concise information on why each attribute was chosen and why it mattered for hydropower production. The utility function that we have considered is the following:

Equation 4

$$U_{ni} = \beta_1 \times fish2 + \beta_2 \times hydro2 + \beta_3 \times wquality2 + \beta_4 \times wqaulity3 + \beta_5 \times bill + \varepsilon_{ni}$$

where *fish2* is the dummy for satisfactory level of fish population; *hydro2* is the dummy for the natural level of hydro-morphology; *wquality2* and *wquality3*, instead, are dummies for good and very good level of water quality; *bill*, finally, represents the cost increase with respect to the maximum rebate. For the sake of understanding, in fact, to all level of rebates, we have subtracted the maximum level of rebate to create the variable *bill*: this guarantees that we obtain the standard negative sign for the monetary component of a WTP estimation. All betas represent the marginal utility of each attribute. Below, we display the results.

Variable	CL		RPL		
	Coefficient	Std. error	Coefficient	Std. error	Coefficient std. dev.
<i>Random parameters (RPL)</i>					
fish2	1.184084***	0.1735208	2.169009***	0.39963	1.937563***
hydro2	0.4481714***	0.1979975	0.708363**	0.3579055	1.769222***
wqaulity3	0.5389399***	0.1745646	0.9831765***	0.31508	1.452827***
<i>Non random parameters (RPL)</i>					
bill	-0.0063373*	0.0037652	-0.0086729**	.0046232	
wquality2	0.542481***	0.1495472	0.9922118***	0.1938956	
<i>Heterogeneity in mean (RPL)</i>					
noactivity*fish2	-0.0830789	0.1967004	-0.1867184	0.4669838	
noactivity*hydro2	0.1935158	0.1746668	0.3188637	0.414731	
noactivity*wqaulity3	0.0981564	0.1562516	0.0766876	0.3459304	
vicinity*fish2	0.0479222	0.2884071	-0.1673958	0.6518002	
vicinity*hydro2	0.4718627*	0.2643574	0.4304723	0.5784721	
vicinity*wqaulity3	0.2031643	0.2271253	0.1295728	0.4971679	
Individuals	200		200		
Observations	4.800		4.800		
Replications			400		
Significant	*** at 1% ** at 5% * at 10%		*** at 1% ** at 5% * at 10%		

Table 3: Conditional and Random Parameters Logit for Main Water Bodies.

All of the attributes are significant and with the expected sign. The comparison between the CL and the RPL shows how taking into account heterogeneity permits to better estimate the coefficients. Not surprisingly, the most important attribute is fish population: people are willing to preserve the wild salmon and the sea trout population. It is important to highlight that doing leisure activities in the Aspe valley and living within 1 km from the river do not influence the results.

The results of the models permit to estimate the marginal willingness to pay. As anticipated before, the betas can be seen as the marginal utility of each level of each attribute; therefore, observing the choices that individuals make when some attribute level changes and observing the price associated with this particular scenario of change, we can derive marginal values for each attribute when moving from the opt-out level to each other level of the attribute, according to the formula:

Equation 5

$$MWTP_{x,a} = -\frac{\beta_{x,a}}{\beta_p}$$

where $MWTP_{x,a}$ is the marginal willingness to pay to move from the opt-out level to level a of attribute x ; $\beta_{x,a}$ is the marginal utility of level a of attribute x ; β_p is the marginal utility of money.

Variable	CL (€/year)	RPL (€/year)
fish2	186,84	250,09
hydro2	70,72	81,68
wqaulity2	85,60	114,40
wqaulity3	85,04	113,36

Table 4: Marginal willingness to pay for attributes (90% confidence interval).

Table 4 shows that households have a significant marginal willingness to pay and that both models give similar results. As already anticipated above, MWTP for a satisfactory fish population is considerable: between € 187 and € 250 per household per year. Households are also willing to pay for natural flow and higher water quality.

These estimates can be used to calculate the total WTP for different management scenarios. Since the utility function that we are using is linear, its value is the sum of its parts, that is, attributes can be combined in different ways to estimate welfare effects of discrete changes of the set of attributes. This situation can be calculated with the log-sum formula (Hanemann, 1999):

Equation 6

$$E(WTP) = \frac{1}{-\beta_p} (\ln e^{V_n^1} - \ln e^{V_n^0})$$

Where V_n^1 and V_n^0 represent the utility after and before the change and β_p is the marginal utility of money.

Scenario	CL (€/year)		RPL (€/year)	
	Single Household	Aspe households	Single Household	Aspe households
From status quo to satisfactory fish population, natural flow and very good water quality	111,86	1.286.370	144.08	1.656.967
From status quo to satisfactory fish population and natural flow	74.92	861.635	94.85	1.090.794

Table 5: Compensating surplus (WTP) for different scenarios.

As shown in scenario 2, the willingness to pay for a pristine Aspe (that is a satisfactory level of fish population, a very good water quality and a natural flow), is estimated between € 112 to € 144 euro per household per year. Considering that in the Aspe region there are a bit less than 13.000 households, the cumulated willingness to pay is not far from € 2 million euro. Moreover, the WTP is higher than the maximum rebate that hydropower operators could offer, meaning that the fluvial ecosystem is something that really matters to the local community.

Let's now compare our results with the restoration costs estimated during the accident. Restoration costs varied between € 97,000 and € 121,000, according to the area to be recovered. It is important to bear in mind that the operations carried out were just to recover a part of the Aspe to its previous status, the one that we consider as the *status quo* in our questionnaire. This means that the results are not comparable as they refer to different levels of ecosystem improvements. Still, they can give a hint of the differences between the methods. Considering that the households living in that same area are a bit less than 1,200, we can show the results, taking into account both scenarios.

€	Restoration	CL	RPL
Cost/Value	97,000 - 121,000	89,910 - 134,230	113,882 - 172,901

Table 6: Comparing restoration costs with the compensating surplus for different scenarios.

It is immediate to see that restoration costs underestimate the value of the ecosystem. The cost of restoring the upper part of the Aspe is lower than the perceived value of improvements from the current status to better fluvial ecosystem situations. These results show once again that people considerably value the environment they live in.

5 Final remarks

In the next years, France will have to renew the Concession of a consistent part of its hydropower capacity. Beauty contests will take place, where bidders have to present offers for technical and environmental improvement, as well as a revenue sharing percentage for Local Authorities.

This framework generates a potential trade-off between revenue-sharing and environmental improvements. Both potential bidders and Authorities should be interested in estimating the value of the fluvial ecosystem and people's willingness to pay for pristine rivers. This knowledge should bring about a better structured beauty contest and more effective bids.

Consequently, the paper investigates this potential trade-off between a better environment and a higher percentage of money handed down to Local Authorities by estimating people's preferences, with a discrete choice experiment.

The peculiarity of the DCE we have conceived is that we have translated the revenue sharing in an immediate rebate in the electricity bill. Respondents could choose higher rebates and lower ecosystem improvements or lower (or no) rebate and higher ecosystem amelioration. In real life, there will be no rebate; still, an increased amount of money for local communities should mean either less local taxes or better local services. This explain why we targeted only households in the Aspe region: a consistent part of the revenue sharing percentage will, in fact, accrue to local authorities.

The paper shows that people are willing to pay to increase the ecological status of the Aspe river; the highest total willingness to pay (WTP) is above € 144 per household and per year.

Results show that people's MWTP for a specific attribute can reach 250 €/year, that is three the maximum rebate that was offered. Moreover, all environmental attributes are considered as significant and worth a monetary effort.

The implication of this study are straightforward: people value considerably the improvement of the Aspe ecosystem and they value it more than its actual restoration costs. This means that the beauty contest should stress this element throughout the process. Moreover, bidders should react accordingly and develop specific strategies for increasing their chances, by offering more on environmental improvements.

Of course, there is scope for further research. The results of the DCE could be largely influenced by its design, so it could be useful to replicate the study, not only in the Aspe, but for all other rivers where the concession renewal is going to take place.

Acknowledgements

A. Cretì gratefully acknowledges financial support from the Ecole Polytechnique Chair EDF-Sustainable Development, and the Business Sustainability Initiative at Europlace Institute of Finance.

References

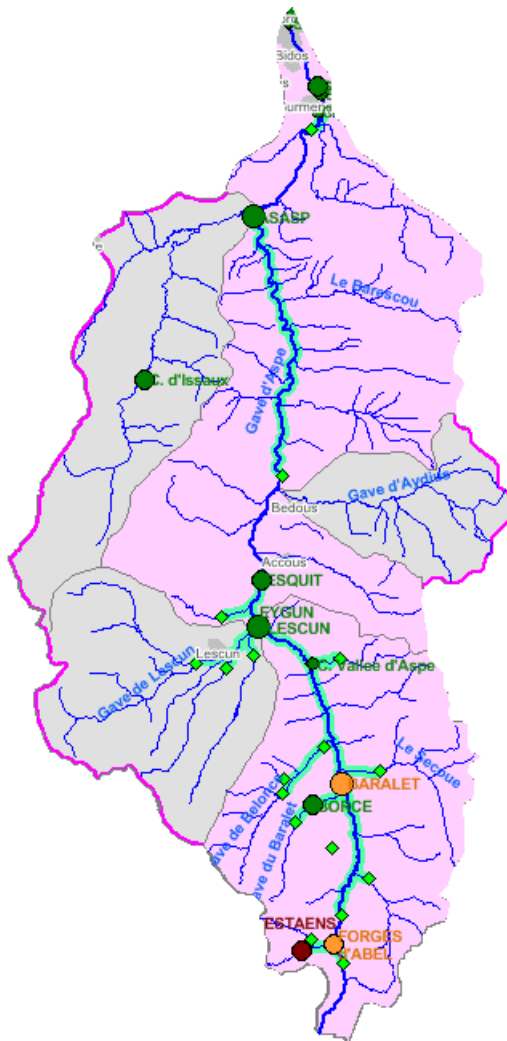
- Alvarez-Farizo, B., Hanley, N., Barberan, R., Lazaro, A., 2007. Choice modeling at the “market stall”: individual versus collective interest in environmental valuation. *Ecological Economics*, 60, 743–751.
- Aquitaine, Direction Régional de l’environnement (DRE), 2008. Plan de gestion de poissons migrateurs 2008–2012.
- Bateman, I., Carson, R., Day, B., Hanemann, M., Hanley, N., Hett, T., Jone-Lee, M., Loomes, G., Mourato, S., Ozdemiroglu, E., Pearce, D., Sugden, R., Swanson, J., 2002. *Economic Valuation with Stated Preference Techniques: A Manual*. Edward Elgar Publishing Limited, Cheltenham.
- Birol, E., Koundouri, P., Kountouris, Y., 2008. Using the choice experiment method to inform river management in Poland: flood risk reduction versus habitat conservation in the upper Silesia Region. In: Birol, E., Koundouri, P. (Eds.), *Choice Experiments Informing Environmental Policy*. Edward Elgar, Cheltenham, UK.
- Bratrich C, Truffer B., 2001. *Green Electricity Certification for Hydropower Plants—Concepts, Procedure, Criteria*. EAWAG Ökostrom Publikationen 7: Kastanienbaum.
- Brouwer, R., Martin-Ortega, J., Berbel, J., 2010. Spatial preference heterogeneity: a choice experiment. *Land Economics*, 86, 552–568.
- Brown, L.E., Hannah, D.M., Milner, A.M., 2007. Vulnerability of alpine stream biodiversity to shrinking glaciers and snow-packs. *Global Change Biology*, 13, 958–966.
- Céréghino, R., Cugny, P., Lavandier, P., 2002. Influence of intermittent hydro-peaking on the longitudinal zonation patterns of benthic invertebrates in a mountain stream. *International Review of Hydrobiology*, 87, 47–60.
- Chanseau M., Larinier, M., Travade, F. 1999. Efficacité d'un exutoire de dévalaison pour smolts de saumon atlantique (*salmo salar* L.) et comportement des poissons au niveau de l'aménagement hydroélectrique de Bedous sur le gave d'Aspe étudiés par la technique de marquage-recapture et par radiotélémetrie. *Bulletin France Pêche Piscicole*, 353/354, 99–120.
- Commission Régulation de L’Energie, 2013. Annual Report.
- Compagnie National du Rhône (CNR) , 2013. Annual Report.
- Croze, O., Bau, F., Delmouly, L., 2008. Efficiency of a fish lift for returning Atlantic salmon at a large-scale hydroelectric complex in France, *Fisheries Management and Ecology*, 15, 467-476.
- D. McFadden. Conditional logit analysis of qualitative choice behaviour. In Zarembka P. (Ed.), *Frontiers in Econometrics*, Academic Press, New York, 1973.
- Doherty, E., Campbell, D., Hynes, S., 2013. Models of site-choice for walks in Ireland: exploring cost heterogeneity. *Journal of Agricultural Economics*, 64(2), 446-466.
- Hanemann, M., 1999. Welfare analysis with discrete choice models. In: Herges, J., Kling, C. (Eds.), *Valuing Recreation and the Environment*. Edward Elgar, Cheltenham, pp. 33–64.
- Hanley, N., Adamowicz, W., Wright, R., 2005. Price vector effects in choice experiments: and empirical test. *Resource and Energy Economics*, 27, 227–234.

- Hanley, N., Wright, R., Alvarez-Farizo, B., 2006. Estimating the economic value of improvements in river ecology using choice experiments: an application to the water framework directive. *Journal of Environmental Management*, 78, 183–193.
- Hoyos, D., 2010. The state of the art of environmental valuation with discrete choice experiments. *Ecological Economics*, 69, 1595–1603.
- Hynes, S., Hanley, N., Scarpa, R., 2008. Effects on welfare measures of alternative means of accounting for preference heterogeneity in recreational demand models. *American Journal of Agricultural Economics*, 90, 1011–1027.
- Joskow, P., 2008. Incentive regulation and its application to electricity networks. *Review of Network Economics*, 7(4), 547-560.
- Kataria, M., 2009. Willingness to pay for environmental improvements in hydropower regulated rivers. *Energy Economics* 31, 69–76.
- Kataria, M., Bateman, I., Christensen, T., Dubgaard, A., Hasler, B., Hime, S., Ladenburg, J., Levin, G., Martinsen, L., Nissen, C., 2012. Scenario realism and welfare estimate in choice experiments – a non-market valuation study on the European Water Framework Directive. *Journal of Environmental Management*, 94, 25–33.
- Kragt, M., Newham, L., Bennett, J., Jakeman, A., 2011. An integrated approach to linking economic valuation and catchment modelling. *Environmental Modelling & Software*, 26, 92–102.
- Ministère de l'Écologie, du Développement Durable, de Transport et du Logement, 2011. *Application des méthodes d'équivalence à la pollution accidentelle du Gave d'Aspe*, Paris.
- Metcalf, P., Baker, W., Andrews, K., Atkinson, G., Bateman, I., Butler, S., Carson, R., East, J., Gueron, Y., Sheldon, R., Train, K., 2012. An assessment of the nonmarket benefits of the water framework directive for households in England and Wales. *Water Resource Research*, 48 (W03526),
- Morrison, M., Bennett, J., 2004. Valuing New South Wales rivers for use in benefit transfer. *Australian Journal of Agricultural and Resource Economics*, 48, 591–611.
- Nilsson C., 1996. Remediating river margin vegetation along fragmented and regulated rivers in the north: what is possible? *Regulated Rivers: Research and Management*, 12, 415–431.
- Poirier, J., Fleuret, A., 2010. Using the choice experiment method for valuing improvements in water quality: a simultaneous application to four recreation sites of a river basin. In: Proceedings of the 59th Conference of Association Française de Science Economique. Nanterre Université.
- Renofalt, B. M., Jansson, R., Nilsson, C. 2010. Effects of hydropower generation and opportunities for environmental flow management in Swedish riverine ecosystems. *Freshwater Biology*, 55 (1), 49-67.
- Stithou, M., Hynes, S., Hanley, N., Campbell, D., 2012. Estimating the value of achieving “Good Ecological Status” in the Boyne River Catchment in Ireland using choice experiments. *The Economic and Social Review*, 43, 397–422.

Annex

The English translation of the survey made in the Aspe Region.

Paris X University and Bocconi University (Italy) are working on a research program, whose purpose is to provide a tool for assessing the environmental costs of operating hydroelectric concessions. The Aspe River is one of the mountain streams that have been selected for this research, which entails a survey to study households' attitude towards hydropower production.



Aspe River

The Aspe River is listed as one of the "Natura 2000" sites. The Natura 2000 network concerns natural or semi-natural areas of the European Union of great heritage value, because of their exceptional flora and fauna.

We remind you that the survey is anonymous.

Section 1

1. You are...
 - a. Male
 - b. Female
2. Your year of birth
 - a.
3. What is the highest level of education you have completed?
 - a. Elementary school
 - b. Junior high school
 - c. High school
 - d. University degree
 - e. Other _____
4. How many people live in your family (including yourself)?
 - a.
5. Your annual income (in Euro)?
 - a. 0-10,000
 - b. 10,001-20,000
 - c. 20,001-30,000
 - d. 30,001-50,000
 - e. 50,001-100,000
 - f. over100,000
6. At what distance is the Aspe River from your house?
 - a. Less than a kilometre
 - b. Between 1 and 5 kilometres
 - c. More than 5 kilometres
7. Do you practice any leisure activity connected to the Aspe?
 - a. Fishing
 - b. Swimming
 - c. Hiking
 - d. Rafting
 - e. Canoeing
 - f. Hunting
 - g. Studies and research
 - h. Others
 - i. No activity
8. How often you practice those activities:
 - a. Weekly
 - b. Monthly
 - c. More than once per year
 - d. At least once a year
 - e. Less than once a year
9. Are you a member of an environmental organization?
 - a. Yes
 - b. No
10. Are you aware of the fact that in the next years hydropower concessions in the Aspe River will expire?
 - a. Yes
 - b. No



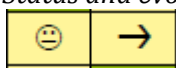
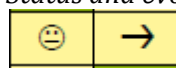
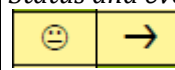



Section 2


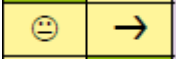

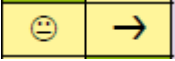



8 scenarios (choice sets) are presented below. They concern the environmental impacts generated by different ways of managing hydropower.




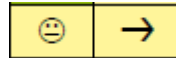
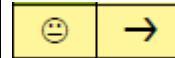



We took into account a limited number of environmental attributes and, similarly, we have considered a limited number of levels of variation for each attribute. Although they are not exhaustive, attributes and levels chosen give a precise idea of the ecosystem under study.





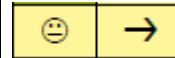



In each scenario, we assume that there are three hydropower producers. Each producer offers annual rebates on your electricity bill. Producer "C" will always offer you the maximum rebate, preserving the current ecosystem status of the Aspe River. On the other hand, producers "A" and "B" will offer smaller discounts, but in each scenario, they will also provide improvements to the Aspe ecosystem.




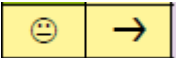
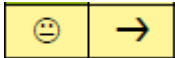



For every choice set, you will be asked to choose the producer you prefer. There are no absurd choices.





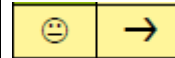



Choice Set 1			
Attributes	Producer A	Producer B	Producer C
Fish <i>Sea trout</i>  <i>Atlantic Salmon</i> 	Not satisfactory <i>Status and evolution</i> 	Not satisfactory <i>Status and evolution</i> 	Not satisfactory <i>Status and evolution</i> 
	Natural	Natural	Artificial
Hydro-morphology			
Physical and chemical water quality	Very good	Good	Sufficient
Rebate in euro (on your yearly electricity bill)	10	40	75
Choice			









Choice Set 2			
Attributes	Producer A	Producer B	Producer C
Fish <i>Sea trout</i>  <i>Atlantic Salmon</i>	Not Satisfactory <i>Status and evolution</i> 	Satisfactory <i>Status and evolution</i> 	Not Satisfactory <i>Status and evolution</i> 
Hydro-morphology	Natural 	Natural 	Artificial 
Physical and chemical water quality	Very good	Good	Sufficient
Rebate in euro (on your yearly electricity bill)	0	10	75
Choice			





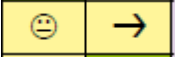



Choice Set 3			
Attributes	Producer A	Producer B	Producer C
Fish <i>Sea trout</i>  <i>Atlantic Salmon</i> 	Satisfactory <i>Status and evolution</i>  Natural	Not Satisfactory <i>Status and evolution</i>  Natural	Not Satisfactory <i>Status and evolution</i>  Artificial
Hydro-morphology			
Physical and chemical water quality	Sufficient	Very good	Sufficient
Rebate in euro (on your yearly electricity bill)	0	0	75
Choice			

Choice Set 4			
Attributes	Producer A	Producer B	Producer C
Fish <i>Sea trout</i>  <i>Atlantic Salmon</i> 	Satisfactory <i>Status and evolution</i> 	Satisfactory <i>Status and evolution</i> 	Not Satisfactory <i>Status and evolution</i> 
Hydro-morphology	Artificial 	Artificial 	Artificial 
Physical and chemical water quality	Very good	Sufficient	Sufficient
Rebate in euro (on your yearly electricity bill)	0	10	75
Choice			

Choice Set 5			
Attributes	Producer A	Producer B	Producer C
Fish <i>Sea trout</i>  <i>Atlantic Salmon</i> 	Satisfactory <i>Status and evolution</i> 	Not Satisfactory <i>Status and evolution</i> 	Not Satisfactory <i>Status and evolution</i> 
	Artificial	Natural	Artificial
Hydro-morphology			
Physical and chemical water quality	Very good	Good	Sufficient
Rebate in euro (on your yearly electricity bill)	40	40	75
Choice			

Choice Set 6			
Attributes	Producer A	Producer B	Producer C
Fish <i>Sea trout</i>  <i>Atlantic Salmon</i> 	Satisfactory <i>Status and evolution</i>  Natural	Satisfactory <i>Status and evolution</i>  Artificial	Not Satisfactory <i>Status and evolution</i>  Artificial
Hydro-morphology			
Physical and chemical water quality	Very good	Very good	Sufficient
Rebate in euro (on your yearly electricity bill)	0	40	75
Choice			

Choice Set 7			
Attributes	Producer A	Producer B	Producer C
Fish <i>Sea trout</i>  <i>Atlantic Salmon</i> 	Satisfactory <i>Status and evolution</i>  Natural	Satisfactory <i>Status and evolution</i>  Artificial	Not Satisfactory <i>Status and evolution</i>  Artificial
Hydro-morphology			
Physical and chemical water quality	Good	Very good	Sufficient
Rebate in euro (on your yearly electricity bill)	10	40	75
Choice			

Choice Set 8			
Attributes	Producer A	Producer B	Producer C
Fish <i>Sea trout</i>  <i>Atlantic Salmon</i> 	Not Satisfactory <i>Status and evolution</i> 	Not Satisfactory <i>Status and evolution</i> 	Not Satisfactory <i>Status and evolution</i> 
	Artificial	Natural	Artificial
Hydro-morphology			
Physical and chemical water quality	Very good	Sufficient	Sufficient
Rebate in euro (on your yearly electricity bill)	10	40	75
Choice			