Cheaper electricity or a healthier river?

Estimating fluvial ecosystem value in Southern France

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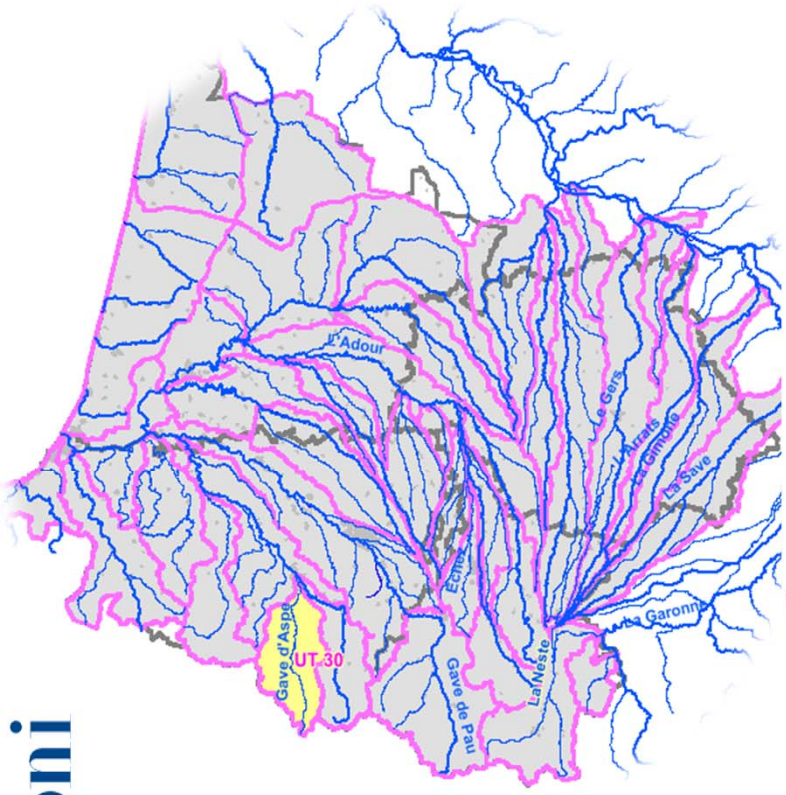
Outline

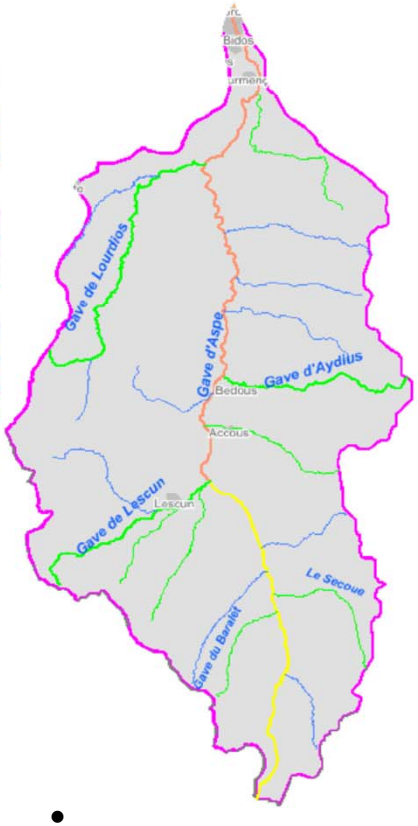
- Introduction
  - Policy and geographical background
  - Research question and bidding vehicle
- Structure of the study
  - Delphi analysis
  - Determination of the bidding vehicle
  - Choice experiment methodology and design
  - Econometric model
- Results
  - Preference space
  - WTP space
  - Compensating surplus
- Final remarks

Introduction

- Current situation
  - Hydropower concession renewals are about to take place
    - Beauty contest based on
      - Technical offer
      - Economic offer: percentage of the turnover
      - Environmental offer
    - There is an emerging trade-off between rent-sharing and environmental improvements, dictated by the Water Framework Directive
  - 2/3 of the expected revenue sharing fee will be handed down to Local Authorities

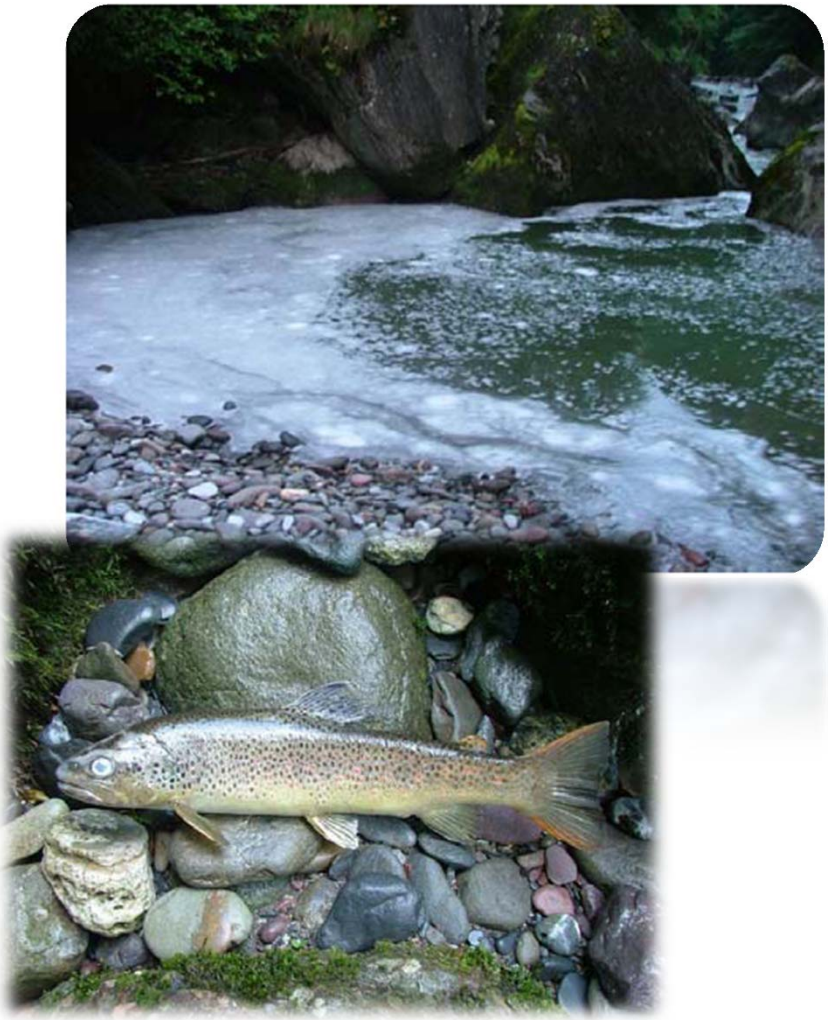
Introduction – 2





- The Aspe is a 48-km river part of Natura 2000, an ecological network of protected areas within the European Union
- It is one of the last rivers where salmons and sea trouts reproduce
- It is home to16 hydropower plants (total capacity of 93 MW), whose concessions are to expire
- In the Aspe Region there are approximately 11 500 households (INSEE, 2013), of which 1200 live in the area were the accident took place.

Introduction – 3



- in 2007, a car accident resulted in the discharge of 17 000 litres of potassium hydroxide into the river, destroying 4 kilometers of fauna and severely affecting the upper portion of the river
- This led to an immediate ban on fishing that lasted 5 years and to the adoption of mitigation measures
- After seven years, the ecosystem has recovered, but the accident has increased environmental awareness among the local population
- Moreover, it has demonstrated the importance of the natural flow: all hydropower operators were forced to release water to dilute the potassium hydroxide, allowing the river to act as a natural depurator
- Direct cost of restoration: 150 K€

Rationale and bidding vehicle

- In the renewal procedure, bidders are asked to offer a percentage of revenue sharing and an improvement of the fluvial ecosystem
- We expect that offers of higher environmental improvements will coincide with offers of lower revenue sharing – that is, we have a tradeoff
  - Environmental mitigation measures consist of:
    - Infrastructural investments, such as fish bypass and retention basins
      - Increase in capital costs
    - Management choices, such as increased flow into the river
    - Reduction of water accumulation and reduction of hydropeaking
- Operators need to know what people living close to a regulated river prefer

Rationale and bidding vehicle – 2

- Strategic bidding: optimal combination of environmental measures and revenue sharing
  - 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%
- Regardless of the specific combination, the existing situation for local communities will not worsen. On the contrary, no matter the combination, local communities will be better off.
- Thus, our questionnaire is designed to investigate whether people prefer higher levels of ecosystem mitigation or higher percentages revenue sharing with local authorities.
  - We have imagined that this revenue sharing percentage can be translated into immediate rebates in the electricity bill, as an increased amount of money for Local Authorities should mean either less local taxes or better services

Rationale and bidding vehicle – 3

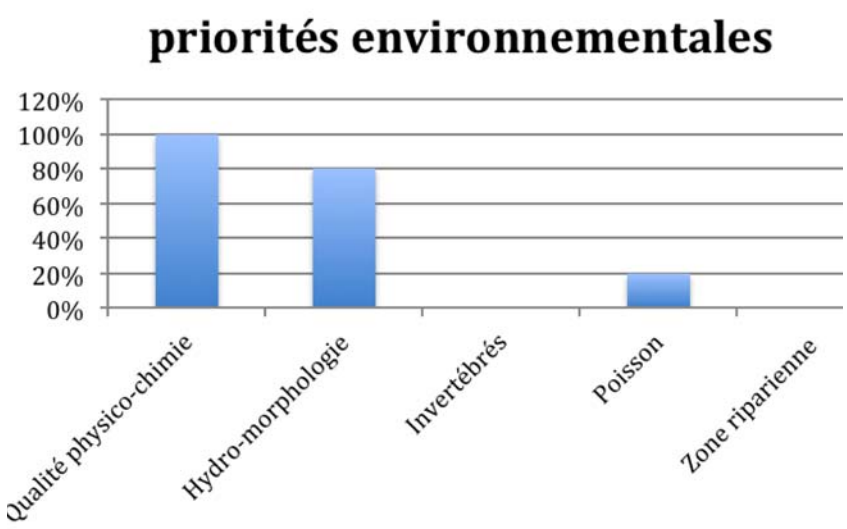
- Notwithstanding the rebate, the choice experiment has a **WTP approach as people's current situation will never worsen**. We ask participants whether they are willing to renounce money they could spend on something else in favor of a healthier fluvial ecosystem.
- The maximum rebate (€ 75) was determined taking into account the amount that could accrue to a single household, according to:
  - the average electricity price on the Power Exchange for 2013 was approximately 50 €/MWh (CRE, 2013)
  - the French law, wherby 75% of the revenue sharing is allocated to the local authorities (Code de l'Energie)
  - the revenue sharing set at 25%, as paid by the CNR

Steps and sources of the research

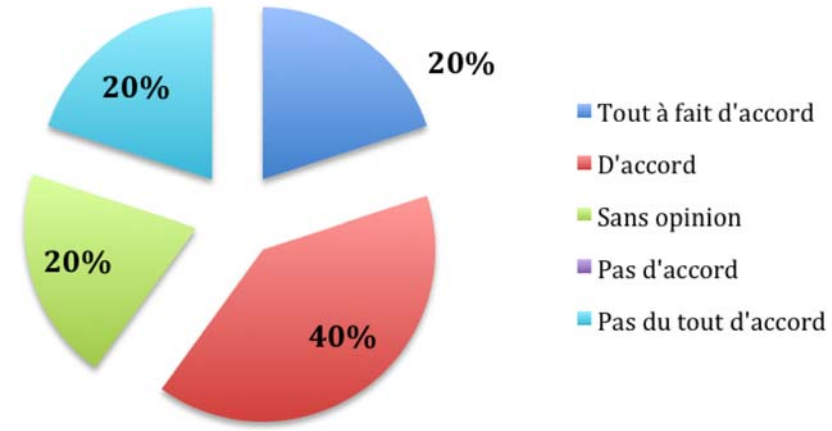
- Delphi analysis to define the relevant attributes for the Aspe river
- Conduct a DCE in the Aspe valley to estimate people's preferences and the monetary value of the River Aspe
- Data collection
  - Environmental externalities come from the results of the Delphi analysis and studies done by the Water Agency
  - Sampling programming and data collection done by Toluna

Delphi Analysis

- Attributes and levels relevant for the Aspe River ecosystem were chosen using a Delphi survey coordinated by the local Water Agency (Agence de l'eau Adour-Garonne), which involved 15 selected experts.
- The Delphi survey was critical also to confirming that various hydropower management regimes effectively increase the quality of the fluvial ecosystem



Please indicate the environmental priorities



Is it possible to improve the fluvial ecosystem by managing hydropower differently?

Discrete Choice Experiment (DCE)

- Methodology
  - The values of environmental externalities have been estimated by a Discrete Choice Experiment (DCE)
    - Given the multidimensional nature of ecosystems, the method most capable of estimating how a combination of changes to one or more ecosystem services affects human welfare is DCE (Hoyos, 2010)
    - DCE involves the design of a hypothetical market, in which people have to choose their preferred "product", decomposed in some relevant attributes, each of which has more than one level.
    - For environmental goods, it is important to relate the change of attribute levels to a change in policy or a change in managing the resource
    - The DCE format allows:
      - marginal utility estimates for changes in the level of each attribute to be easily converted to WTP estimates
      - 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.

DCE Design

- The value of the Aspe ecosystem
  - 3 attributes to describe the river: *water quality, fish population and hydro-morphology.*

Attribute and attribute levels	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

DCE Design – 2

- CAWI questionnaire to 200 representative households
- 8 choice sets containing three alternatives, inclusive an opt out alternative, which was included in all of the choice sets
  - Choice sets with orthogonal design
- Alternatives labeled as "electricity supplier *x*"(with *x* ranging from 1 to 3), following Kataria (2009). For the sake of the choice experiment, suppliers differ from each other for their remedial measures (that is for the level of the environmental attributes attained) and for the rebate

DCE Design – 3

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

Econometric model

- Econometric regression
  - Random Utility Model, developed by McFadden (1974)
    - the utility for an individual is composed of an observable component and a random component

$$U_{nit} = \alpha_n c_{nit} + \beta_n x_{nit} + \varepsilon_{nit}$$

    - where α_n and β_n are individual-specific coefficients for the cost and other attributes; ε_{nit} is the error term assumed to be extreme value distributed with variance given by $\mu_n^{2(}\Pi^2/6)$, μ_n being an individual-specific scale parameter.
    - Given different alternatives, the probability of an alternative being chosen is expressed on terms of the logistic distribution; this means that individual choices are based on utility differences between alternatives
    - We opt for the more flexible random parameter logit which takes into account the heterogeneity of respondents

$$Prob_{nit} = \int \frac{exp(x'_{nit}\beta)}{\sum_{j=1}^{J} exp(x'_{njt}\beta)} f(\beta|\theta)d\beta$$

Econometric model – 2

- where $f(\beta|\theta)$ is the density function of β.

- Empirically, the estimation of a MXL model involves
  - Determination of the randomly distributed parameters
  - Choice of the mixture distribution for the random coefficients
  - In preference space the parameters of random coefficients' distribution are estimated with either classical maximum likelihood or Bayesian estimation techniques.
    - The (WTP) for an attribute is then the ratio of the attribute coefficient to the monetary coefficient
  - This can lead to heavily skewed WTP distributions with no defined moments. To address this issue the monetary coefficient is often specified as fixed

Econometric model – 2

- the model in preference space can be specified by dividing Equation (2) by μ_n , which returns a model in WTP space
- Although both Equations spaces are equivalent in nature, the WTP specification allows direct specification of the distribution of WTP rather than deriving it from the ratio of two coefficients. In practice, the WTP space specification has the advantage of avoiding arbitrary choice of the WTP distribution that arises in the standard preference space procedure

Sample – descriptive statistics

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

Results in preference space

	Model 3 : MXL	Model 4 : MXL (corr)
	Non-random parameters	
Bill	*-0.008** (0.003)*	*-0.007** (0.003)*
wquality2	*1.004* (0.140)*	*1.157* (0.143)*
	Random parameters	
fish2	*2.114* (0.205)*	*2.214* (0.196)*
hydro2	*0 .980* (0.200)*	*1.182* (0.213)*
wquality3	*1.093* (0.154)*	*1.323* (0.195)*
	Standard deviation	
hydro2	*1.757* (0.161)*	*1.994* (0.183)*
fish2	*1.875* (0. 200)*	*1.669* (0.193)*
wquality3	*1.389* (0.137)*	*1.717* (0.164)*
N	4800	4800
Log-Lik.	*-1323.7*	*-1279.1*
AIC	*2663.4*	*2580.2*
BIC	*2715.2*	*2651.4*

Note: *,** denote rejection at 1% and 5% significance levels. Between parentheses are standard errors. Estimation of model 3 is obtained from 2000 Halton draws simulations, and model 4 from 2500 Halton draws simulations.

Results in preference space – 2

- Marginal willingness to pay

	Model 3	Model 4
fish2		
Mean	*256.6*	*277.6*
Median	*461.2*	*335.7*
SD	*219.6*	*238.4*
hydro2		
Mean	*119.0*	*148.2*
Median	*137.5*	*198.5*
SD	*234.3*	*284.8*
wquality3		
Mean	*132.7*	*165.9*
Median	*132.5*	*208.5*
SD	173.6	245.2

Results in WTP space - MWTP

	Model 5	Model 6
fish2		
Mean	*235.3*	*221.8*
Median	*244.5*	*235.3*
SD	*236.7*	*132.2*
hydro2		
Mean	*112.2*	*118.0*
Median	*117.0*	*138.2*
SD	*165.0*	*167.0*
wquality3		
Mean	*120.2*	*132.4*
Median	*130.8*	*146.3*
SD	*130.4*	*146.5*
Log-likelihood	*-1322.8*	*-1282.1*
AIC	*2663.6*	*2682.2*
BIC	*2721.9*	*2759.9*

Compensating surplus

- Scenario 1: From opt out to satisfactory fish population, natural flow and very good water quality

- Scenario 2: From opt out to satisfactory fish population, natural flow and sufficient water quality

	Model 4		Model 6	
	Single Household	Aspe households	Single Household	Aspe households
Scenario 1	*1 225.08*	*15 926 040*	*922.14*	*11 987 820*
Scenario 2	*905.96*	*11 777 480*	*643.57*	*8 366 410*

	Restoration	Model 4	Model 6
Cost/Value (€)	*150 000*	*1 087 152 - 1 470 096*	*772 284 - 1 106 568*

Final remarks

- 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 € 1 225 per household and per year
- The implication of this study is straightforward: people value considerably the improvement of the Aspe ecosystem, which 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.

Bocconi

Thank you!

EconomiX