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"Bargaining over Environmental Budgets: A Political Economy Model with Application to French Water Policy"

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1 Introduction

Environmental decision makers often rely on consultative committees or legislative boards for budget allocation issues. There is a growing literature on the properties of environmental planning systems in which such governance implies negotiation between stakeholders. Negotiation and bargaining models are for example applied to pollution control problem (Carraro and Siniscalco, 1993; Van Egteren and Tang, 1997; Wang et al., 2003), agreements on greenhouse gas mitigation (Weikard, 2010; Lessmann et al., 2015), management of global biodiversity (Gatti et al., 2011), the choice of environmental policy instruments under strategic voting (Hattori, 2010), and water issues (Carraro and Sgobbi, 2011 and the survey by Carraro et al., 2005). Indeed, the management of water resources is an interesting and important example: in many countries, management is decentralized at the river basin (or water district) level, and water users are represented in consultative committees while contributing to a common budget through a tax policy.

More precisely, in such institutional setting, a budget raised from water use charges or emission taxes is redistributed between resource users public funding of projects of general or categorical interest, under a balanced budget restriction. Because of the diversity of services provided by water to residential users, industry, agriculture and ecosystems, the range of projects financed by environmental agencies is potentially large, as well as the diversity of tax revenues. The rules under which the redistribution takes place are an important part of the environmental policy and their relevance for environmental protection is a matter of environmental political economy. Such water management systems with earmarked budgets and local water boards (or river basin committees) are found in several countries such as Belgium, France, Italy, Mexico, Portugal and Spain (OECD, 2011).

It should not be surprising that there are winners and losers from such budget distribution, as the intensity of water use and the nature of resource and environmental projects potentially financed vary largely over user categories. Nevertheless, from a purely redistributive perspective, water users may oppose excessive differences between the level of tax payments and subsidies they receive, particularly in contexts where subsidies are aimed at promoting water-saving and emission abatement projects, precisely to reduce the burden of tax. This is precisely the case in France, where taxes are collected by Water Agencies on water use and effluent emissions from three major user categories: residential users, industry and agriculture, and are then used to finance specific or general-interest projects for resource conservation or availability. By doing so, Water Agencies are applying a principle of "river basin solidarity" among water users, which is part of the French Water Law since 1964. Recently however, the French audit office has questioned the functioning of the Water Agencies (Cour des Comptes, 2015). One of the main critiques is that there is a persistent imbalance between the amount of taxes paid and the subsidies received by the different categories of water users, agriculture being always favoured by the system.

Although the observed discrepancies between relative tax payments and subsidies can be explained by the relative weights of water user categories in committees, the negotiation process within committees can also play an important part. More precisely, the nature of coalition formation in water boards may be an additional factor to explain observed gaps between tax payments and subsidies. Moreover, water user representatives may find it preferable to bargain over a fraction of the budget only, so as to secure a predetermined share of the budget in the form of subsidies.

To determine whether the nature of bargaining and coalition formation within committees, as well as the possibility to secure a fixed part of the budget from bargaining, play a role in final decisions from water boards, a specific model is called for. The contribution of this paper is twofold. First, we model the negotiation process within a water board as a noncooperative bargaining game where players include representatives of water users and the State. An important aspect when considering a model of bargaining applied to water management decisions, is the fact that the latter may not reflect the observed distribution of water user representatives in the water boards. Indeed, a representative may need to form a coalition with other user representatives, to make sure his proposal will be accepted. A major determinant is therefore the weight each category has in the committee, as well as the probability that a particular representative will have the initiative to make a proposal upon the budget to be distributed. Another particular aspect of our bargaining model is the fact that representatives negotiate, not only over the share of budget to be distributed among water user categories, but also on the fraction of the budget that will be bargained upon, hence leading to a two-stage game. It is likely that, because of risk aversion and preferences for stability over time of budget shares, representatives in water boards prefer to exclude a fixed proportion of the budget from bargaining.

Second, we perform a structural estimation of the bargaining model, with an application to the French water policy. In the special case with three water user categories characterized by Constant Relative Risk Aversion (CRRA) preferences, we show that a closed-form solution exists and that there is a systematic gain for water users associated with a particularly low share of total tax payments. Our structural estimation includes preference parameters and the share of budget that is bargained upon. We test whether our assumptions on the two-stage structure of the game are valid, i.e., whether bargaining occurs over the full budget or not at all. Furthermore, we compare our structural estimation with reduced-form estimates that only predict budget shares without imposing any particular assumption on the negotiation process. A non-nested test procedure is used to compare the structural model estimation with reduced-form estimation, as in the empirical literature on bargaining models that does not go beyond identification of major determinants of budget allocation, i.e., representative power and/or economic "needs" as in Kauppi and Widgren (2004).

We are also able to examine the impact of the nature of the negotiation process over the final budget distribution, as structural estimates can be used to derive probabilities for water user representatives to act as proposers of particular budget distributions. In particular, such estimated probabilities may be different from observed representation of water users in water boards, which may form an additional factor for explaining tax-subsidy gaps for some water user categories.

The outline of the paper is as follows. In Section 2, we present the bargaining model in the general case of a water board (or river basin committee) with water user representatives. We adopt a game-theoretical approach consisting of two stages: determination of the optimal share of budget to be bargained upon, and computation of the equilibrium payoffs from negotiation between players over the distribution of the residual budget.

In Section 3, we consider the French Water Agencies and River Basin Committees as a particularly relevant application. We first show that, in the special case of three water user categories, closed-form solutions to the bargaining game are available. This case matches well the actual situation with residential users, agriculture and industry as the major categories concerned by the water policy. We then briefly discuss the French water policy and present the data, before proceeding to structural model estimation. We test for the assumption that budget is either not bargained upon (and relative budget shares correspond to tax shares), or whether the full budget is subject to bargaining. Rejection of these assumptions provides us with evidence that a two-stage model with bargaining over partial budget is valid. Finally, we compare our structural estimation with a reduced-form system of equations and use a non-nested test procedure to discriminate between the two approaches. Section 4 concludes.

2 The Bargaining Model

In this section we introduce the bargaining model applied to water management by a water board (or river basin committee). We assume that the tax policy is predetermined, and we focus on the distribution of the budget raised from taxes among user categories in terms of subsidies. A convenient representation is to consider a sequential bargaining game with two stages, because it embeds a majority of actual situations possibly as special cases (no bargaining, bargaining over full budget or a fraction of the budget). In the first stage, players bargain on the fraction of the budget to be distributed proportionally to the taxes paid by the different categories. In the second stage, players bargain on the allocation of the residual budget among user categories.

The theoretical papers closest to our setting are Baron and Ferejohn (1989) and Banks and Duggan (2001), hereafter denoted BF and BD respectively. As in BF, we assume that the policy consists in the distribution of a budget among a set of users. Their bargaining game consists in a (possibly infinite) sequence of stages where at each stage a proposer is selected to make a proposal which is submitted to a vote. If a winning coalition of players vote in favor of the proposal, then the game ends with the proposal implemented.

Also in line with BF, we consider a first stage with a (possibly infinite) sequence of rounds: at each round a proposer is selected to make a proposal which is submitted to vote. If a winning coalition of players vote in favor of the proposal then the game ends and the first stage is completed. The relevant bargaining model is the general BD model which considers arbitrary unidimensional or multidimensional policy spaces. In our second stage, we are back in the policy situation considered by BF but, for the sake of tractability, instead of modelling the second stage as BF did, we model it as an ultimatum game (one round instead of a sequence of rounds).

When solving the two-stage game backwards, the reduced game we obtain is therefore a BD game in which players have rationally anticipated their payoffs in the continuation game. More precisely, given the budget fraction proposed in stage 1 and the residual budget distributed in stage 2, players can calculate their random shares in stage 2. This amounts to calculating the chance of being a proposer and the chance of being listed in a proposal initiated by another proposer. By accepting to go for stage 2, players endorse a risk as the outcome of stage 2 is not known with certainty. In stage 1, their attitude towards risk combined with their characteristics as tax contributors therefore determine their indirect utility for future random payoffs. We will therefore obtain a one dimensional BD bargaining problem, along the lines discussed above.[1]

[1]Several empirical analyses of the BF bargaining model have been conducted, including Knight (2005) on decisions of the US House Committee on Transportation and Infrastructure, Ferejohn (1974) and Lewitt and Poterba (1999) on federal spending and representation by congressional delegations, Eraslan (2008) on bargaining in the BF vein in corporate finance, and Diermeier and Merlo (2004) on the analysis of the formation of coalition governments in Europe.

2.1 Basic Setting

We assume there are n committee members (also referred to as "players"), from which k are representatives of water user categories, $i = 1, \ldots, k$, with $k \leq n$. Non-water users, $j = k+1, \ldots, n$, are stakeholders not directly impacted by committee decisions on budget.

We denote by γ_i the fraction of total taxes paid by the ith category of users:

$$\gamma_i = \frac{t_i}{\sum\limits_{j=1}^{k} t_j}, \tag{1}$$

where t_i is the amount of taxes paid by the ith category of users. We assume, without loss of generality, that $\gamma_1 \leq \gamma_2 \leq \cdots \leq \gamma_k$.

The committee members decide on the distribution of the budget, normalized to 1 without loss of generality, among the k users. The policy space is $X \equiv \left\{x \in \mathbb{R}_+^k : \sum_{i=1}^k x_i = 1\right\}$, where x_i denotes the budget share for user i. Water user representatives are assumed to be concerned exclusively by their own budget share. In contrast, preferences of other (non-user) committee members can possibly concern the welfare of all k categories of users. We assume that each player $j = k+1, \ldots, n$ assigns a weight β_{ij} to user category $i, i = 1...k$, such that for any $j = k+1, \ldots, n$ and $i = 1, \ldots, k$, $\beta_{ij} \in [0,1]$ and $\sum_{i=1}^k \beta_{ij} = 1$. Then, given the vector of shares $x = (x_1, ..., x_k)$ the utility of player $j, j = k+1, \ldots, n$, is

$$u_j\left(x\right) = \sum_{i=1}^{k} \beta_{ij} u_i(x_i), \tag{2}$$

where u_i is a twice continuously differentiable function such that $u_i' > 0$ and $u_i'' < 0$. We refer to the case where all vectors $\beta_j = (\beta_{1j}, \ldots, \beta_{kj}), j = 1, \ldots, n$ have their coordinates equal to 0 except one as the *corner regime*.

Players act both as voters and as proposers. The voting activity is described by a *weighted majority game*. Let q_i denote the voting weight (the number of representatives) of category i. We assume that all other voters have weight equal to 1. The quota Q of the game could be any number between $\left\lfloor \frac{\left(\sum_{i=1}^k q_i\right) + (n-k)}{2} \right\rfloor$[2] and $\left(\sum_{i=1}^k q_i\right) + (n-k)$. Therefore, our framework allows

[2]For any real number x, $\lfloor x \rfloor$ denotes the smallest integer greater than x.

for a wide range of voting mechanisms. When $Q = \left\lfloor \frac{\left(\sum_{i=1}^{k} q_i\right) + (n-k)}{2} \right\rfloor$, to pass the proposal the approval of the majority of members is necessary, while when $Q = \left(\sum_{i=1}^{k} q_i\right) + (n-k)$, unanimity is required. Unless otherwise specified, we assume that Q is the majority quota. We denote by $\mathcal{W}$ ($\mathcal{W}_m$) the set of winning (minimal winning) coalitions.[3]

The distribution of proposal powers is represented by the vector $p = (p_1, p_2, ..., p_n)$ such that $p_i \geq 0$ for all $i = 1, ..., n$, and $\sum_{i=1}^{n} p_i = 1$, where p_i denotes the probability that player i is in charge of making a proposal.

The game has two stages. The first stage is a BD bargaining game on the fraction, denoted α, of the budget distributed proportionally to tax payments. This is a sequential game with a possibly infinite number of rounds. At each round t, a proposer $i(t)$ is selected and makes a proposal $\alpha(i,t)$, which members of the committee may approve or reject. If the subset of members approving the proposal is a winning coalition, the proposal is adopted, and if not, the game moves to round $t+1$ and the procedure is repeated. If the procedure fails, γ is adopted.

If $\alpha = 1$ is selected, the game ends after the first stage and the whole budget is distributed according to γ. However, if $\alpha < 1$ is selected, then there is a second stage during which players negotiate on the distribution of the residual budget $(1-\alpha)$. To keep things simple, instead of considering an infinite game as in the first stage, we model the second stage as an ultimatum (one-stage) game. A proposer i is selected according to the probability vector p to make a proposal $x(i) \in X$ which can be accepted or not by other players. If the subset of players approving the proposal is a winning coalition, it is adopted, otherwise, the vector γ is adopted for the residual budget.

We solve this sequential game backwards, and in the following subsection we proceed with the description of the second stage of the game.

[3]A coalition S is a winning one if and only if $\sum_{i \in S} q_i \geq Q$. If, moreover, by dropping any player j we reverse the inequality, i.e., $\sum_{i \in S \setminus \{j\}} q_i < Q$ for any $j \in S$, then such a coalition S is called minimal winning.

2.2 Second Stage: Distribution of Residual Budget

The outcome of the second stage is the allocation of residual budget $(1-\alpha)$ among categories of users. Nature draws proposer j with probability $p_j \geq 0$, where $\sum_{j=1}^{n} p_j = 1$. Proposer j selects vector $x_j = \{x_{1j}, x_{2j}, \ldots, x_{kj}\} \in \mathbb{R}_+^k$ such that $\sum_{i=1}^{k} x_{ij} = (1-\alpha)$.[4] We denote by S_α such simplex. If a majority of members votes in favor of the proposal, the proposal is adopted. Otherwise, the proposal is defeated and the default option γ is used to allocate the residual fraction of the budget. In what follows we describe the voting response. Voter l votes for the proposal x_j if and only if

$$u_l(\alpha\gamma + x_j) \geq u_l(\gamma). \tag{3}$$

We assume that ties are broken in favor of the proposer.

For the proposal to be accepted, the proposer should consider the cost of "buying" a minimal winning coalition. Letting S be any such coalition, the problem of proposer j can be written as:

$$\max_{x_j \in S_\alpha} u_j(\alpha\gamma + x_j), \qquad \text{such that } u_l(\alpha\gamma + x_j) \geq u_l(\gamma) \text{ for all } l \in S \setminus \{j\}. \tag{4}$$

Let us denote by $C(\alpha, S, j)$ the value of this problem and

$$C(\alpha, j) \equiv \max_{S \in \mathcal{W}_m} C(\alpha, S, j). \tag{5}$$

We also denote by $x_j^*(\alpha)$ for $j = 1...n$ the optimal solution to problem (4) and we proceed as if this solution were unique.

Let us look at the solution for the corner regime under complete information. In such a case, each player $j, j = k+1, ..., n$ acts in favour of a single user group. Letting $M_i\,(m_i)$ denote the group (the number) of representatives in the set $\{k+1, ..., n\}$ acting for user i, we have $\sum_{i=1}^{k} m_i = n - k$.

In such a case, players voting on behalf of category i have weight equal to $w_i = q_i + m_i$. Further, the set of supporters of category i votes in favor of the proposal if and only if

$$x_i \geq \gamma_i(1-\alpha). \tag{6}$$

[4] The component x_{ij} is the share of the budget offered to player i by proposer j.

Things are as if proposer j representing category i makes a proposal to win the votes of a winning coalition in a weighted majority game with $\{1, 2, ..., k\}$ as the set of players and w_i being the weight of player i. The probability of player i to be selected as a proposer is now equal to:

$$\widehat{p_i} = p_i + \sum_{j \in M_i} p_j. \tag{7}$$

The set of (minimal) winning coalitions of this simple game is denoted by $(\widehat{\mathcal{W}_m})$ $\widehat{\mathcal{W}}$.

We have,

$$C(\alpha, S, j) = (1 - \alpha) - \sum_{i \in S \setminus \{j\}} \gamma_i (1 - \alpha) = (1 - \alpha) \left(1 - \sum_{i \in S \setminus \{j\}} \gamma_i \right), \tag{8}$$

and therefore,

$$C(\alpha, j) = (1 - \alpha) (1 - \min_{S \cup \{j\} \in \widehat{\mathcal{W}}_m} \sum_{i \in S \setminus \{j\}} \gamma_i). \tag{9}$$

Equivalently in this case:

$$C(\alpha, j) = (1 - \alpha) \left[1 - \min_{S \cup \{j\} \in \widehat{\mathcal{W}}_m} \sum_{i \in S \setminus \{j\}} \gamma_i \right]. \tag{10}$$

To obtain a closed-form expression for x^*_{ij} (voter i's equilibrium share when j is the proposer) is difficult in the general case, even under our assumption of corner regime, because for any player i, there is a trade-off between the voting weight w_i and the cost reflected by the reservation value γ_i.

2.3 First Stage: Decision on Fixed Part of Budget

The first stage is a one-dimensional BD bargaining game , once we account for the backward solution of the second stage on the residual budget allocation, vector $x^*_j(\alpha)$ for all j, $j = 1, ..., n$. In the first stage of the game, each player i views the choice of α as the choice in a lottery where he receives a prize equal to $x^*_{ij}(\alpha)$ with probability p_j.

The expected utility $V_i(\alpha)$ of player i is equal to:

$$\sum_{j=1}^{n} p_j u_i \left(\alpha \gamma_i + x^*_{ij}(\alpha) \right). \tag{11}$$

Note that when $j \neq i$, player i's equilibrium share x^*_{ij} is either equal to 0 or to $(1-\alpha)\,\gamma_i$. The player's expected utility is therefore based on two numbers: first, the probability denoted by P_i that i is considered in the continuation game when i is not the proposer himself, and second, the coalition S_i of players who receive a positive share in his proposal. Without loss of generality, we assume that S_i does not contain player i. Player i's share x_i can be expressed as:

$$x_i = \begin{cases} \alpha\gamma_i + (1-\alpha)\left(1 - \sum_{j\in S_i}\gamma_j\right) = \gamma_i + (1-\alpha)\sum_{j\in N\setminus(S_i\cup\{i\})}\gamma_j \text{ with probability } \widehat{p}_i, \\ \gamma_i \text{ with probability } P_i, \\ \alpha\gamma_i \text{ with probability } 1-\widehat{p}_i - P_i. \end{cases}$$

We obtain that:

$$V_i(\alpha) = \widehat{p}_i u_i\left(\gamma_i + (1-\alpha)\sum_{j\in N\setminus(S^i\cup\{i\})}\gamma_j\right) + P_i u_i(\gamma_i)$$
$$+(1-\widehat{p}_i - P_i)u_i(\alpha\gamma_i)\,. \quad (12)$$

From our assumptions on u_i, it follows that $V_i''(\alpha) < 0$ for all $\alpha \in [0,1]$, i.e., function $V_i''(\alpha)$ is strictly concave on the unit interval. We denote by α_i^* the (unique) peak for player i. Since all assumptions of Banks and Duggan (2000) are met, we conclude from their results that if all players are perfectly patient, then the equilibrium outcomes of the game coincide with the core and it is equal to the median value α^* of the vector $(\alpha_1^*, \ldots, \alpha_n^*)$.[5]

The following proposition summarizes the properties displayed by the preferred peaks of the different groups.

Proposition 1 *Assume that the utility function* $u_i(x_i)$ *is such that* $u_i(0) = 0$, $u_i' > 0$, $u_i'' \leq 0$, *then* $V_i''(\alpha) \leq 0$ *on* $[0,1]$ *for any* $i, i = 1, ..., k$.

Moreover, there exist threshold values $\underline{\gamma}_i$ *and* $\overline{\gamma}^i$ *such that* $0 \leq \underline{\gamma}_i < \overline{\gamma}_i$ *and:*

[5] This result implies that if n is odd, then the equilibrium is unique. However, if n is even, there is no single middle value, and the median is then can be defined as the mean of the two middle values.

(i) if $0 \leq \gamma_i \leq \underline{\gamma}_i$ $V_i(\alpha)$ *is decreasing on the whole interval* $[0, 1]$*;*

(ii) if $\underline{\gamma}_i < \gamma_i < \overline{\gamma}_i$ $V_i(\alpha)$ *has a unique maximum on the interval* $(0, 1)$ *and it is defined from the equation* $V_i'(\alpha) = 0$*;*

(iii) if $\gamma_i \geq \overline{\gamma}_i$ $V_i(\alpha)$ *is increasing on the whole interval* $[0, 1]$*.*

The thresholds $\overline{\gamma}_i$ *and* $\underline{\gamma}_i$ *are calculated as:*

$$\overline{\gamma}_i = \frac{\widehat{p}_i \sum_{j \in N \setminus (S_i \cup \{i\})} \gamma_j}{1 - \widehat{p}_i - P_i} \tag{13}$$

and

$$\underline{\gamma}_i = \frac{\widehat{p}_i u_i' \left(\sum_{j \in N \setminus S_i} \gamma_j \right) \sum_{j \in N \setminus (S_i \cup \{i\})} \gamma_j}{(1 - \widehat{p}_i - P_i)\, u_i'(0)}. \tag{14}$$

Proof: see Appendix 1.

Part (i) of Proposition 1 states that any player i with relatively low γ_i, i.e., with γ_i below $\underline{\gamma}_i$, prefers to bargain on the whole budget as his preferred $\alpha_i^* = 0$. The reason is that in the bargaining game, player i expects to get more than he obtains under the mechanical rule, i.e., γ_i. Being a "cheap" coalitional partner, he is included in any coalition when he is not a proposer receiving an offer equal to γ_i. When he is a proposer he gets strictly more than γ_i.

On the contrary, part (iii) of the proposition states that any player i with relatively high γ_i, i.e., with γ_i above $\overline{\gamma}_i$, prefers to share the whole budget according to the mechanical rule as his preferred $\alpha_i^* = 1$. The reason is that in the bargaining game, player i being an "expensive" coalitional partner receives no offer when he is not a proposer.

Part (ii) describes an intermediate case: any player i with intermediate value of γ_i, i.e., with γ_i in between $\underline{\gamma}_i$ and $\overline{\gamma}_i$, would like to bargain upon some part of the budget as his $\alpha_i^* \in (0, 1)$.

3 Application

We apply in this section the bargaining model to budget allocation decisions by French Water Agencies, as an interesting example of decentralized water management with negotiation between water user representatives in river basin committees. The ability to obtain closed-form solutions from Proposition 1 derives from an reasonable assumption about the number of users as a special case, which will prove useful in our application.

We first introduce the French water policy, and then discuss relevance of our bargaining model to this special case of environmental management. We then present the data used in the empirical application and introduce the special case of three user categories to derive an estimable system of structural equations. The structural estimation results are presented and compared with reduced-form estimation, including a non-nested test procedure. We also test for special cases where $\alpha^* = 0$ and $\alpha^* = 1$, corresponding to the case of bargaining over full budget and the no-bargaining case respectively.

3.1 Water Policy and Budget Bargaining: The French Water Agencies

Water Agencies in France are at the core of a decentralized water management system at the river basin level, and play as such an essential role in the French water policy since the mid-1960s. The six Water Agencies (Adour-Garonne, Artois-Picardie, Loire-Bretagne, Rhin-Meuse, Rhône-Méditerranée-Corse and Seine-Normandie) can be considered environmental agencies in charge of preserving water resources, both in volume and in quality. French Water Agencies are financing specific- or commun-interest water-related projects from a budget fueled by a variety of water charges and taxes (see Seroa da Motta et al., 2004). This includes emission taxes according to the Polluter-Payer Principle and water use taxes and, in terms of project funding, direct subsidies, low-interest or zero-interest rate loans.

Following the Water Act of 2006, the French Parliament determines the priorities of a multi-year intervention program of Water Agencies together with a ceiling on their budget. Furthermore, the executive board of Water Agencies, composed of a subset of River Basin Committee (RBC) members, decides upon the budget allocation following deliberations of the corresponding RBC.

Users are represented in a RBC that also include nominated representatives of the local and national administration. RBCs are the expression of the decentralized management of the resource by river basin, and are as such often considered the parliament of the river basin, with the Water Agency the executive body in charge of implementing the water policy. River Basin Committees participate to the design of multi-year intervention programs, they determine the major priorities of the Water Agencies, and they vote on the tax basis and emission tax rates. They also discuss the budget allocation for financing local projects regarding water resources. The government determines the number of Basin Committee members, including the representation of each category of users (agriculture, tourism, industry, etc.) There are, by law and in every RBC, 40 percent of members for local communities, 40 percent for user representatives, and 20 percent for representatives of the State. Representatives from the agricultural sector are typically more numerous in River Basin Committees characterized by a higher agricultural activity (Adour-Garonne and Loire-Bretagne).

In practice, an internal subsidy commission consisting of members of the RBC makes recommendations on subsidies to finance water-related projects. The executive board of the Water Agency deliberates on the general conditions for attribution of subsidies, and on the actual granting of subsidies. A proposal is constructed by the executive board and submitted for approval to the River Basin Committee. If it is not accepted by the latter, a new proposal is constructed by taking (some of) the recommendations of the River Basin Committee, until an agreement is reached.

A series of papers have addressed the issue of bargaining over water rights or budgets under the French water policy. Thoyer et al. (2001) and Simon et al. (2006) apply a multilateral, multi-issues bargaining model to analyze negotiations over issues related to water use, water storage capacity and user prices. In their general setting, the policy decision has several dimensions and there are several players including water users as well as environmental groups and representatives of elected local councils. Because their model does not admit closed-form solutions, the authors simulate the model in order to analyze the impact of bargaining power and user heterogeneity among others on the negotiated agreement. As in our setting, these studies highlight the role of the bargaining power and the asymmetries of the disagreement payoffs.[6]

Concerning the motivation for a two-stage game, where α is selected in the first stage and the residual budget is bargained upon in the second stage, there is evidence that members of RBCs are in favour of controlling the degree of uncertainty on the final budget allocation. First, it is reasonable to assume that members of RBCs prefer to avoid sharp changes in budget allocation one year to the next. Second, risk aversion is likely to play a role in the objective of water users to bargain over a residual budget, once a non-random part of the latter is decided upon.

There are various ways to define the stable part of budget: stationary over time, or as a function of observed and predetermined variables such as tax payments. This is this second possibility that we consider here; water users collectively determine the share of budget allocated according to their relative tax burden, and then they bargain over deviations from this simple and "equitable" rule.

Interviews with Water Agency executives and RBC members reveal that their policy is to maintain a reasonable stability in subsidies granted to water user categories from one year to the next. Although there is no formal rule about such trend, this is an indication that a proportion of the budget is decided upon as a reference point, independently from a subsequent discussion about projects to be financed. Such reference point is difficult to evaluate in practice because it is determined after negotiation among representatives within each RBC. However, it is reasonable to assume that this proportion of the budget is related to tax payments of each user category, because the total tax paid by users is decided upon by River Basin Committees in advance for the full multi-year programme and is not renegotiated until the next programme.

An interesting feature of our model is that it includes as special cases the absence of bargaining (equivalent to $\alpha = 1$) and bargaining over the full budget (when $\alpha = 0$). Therefore, these two polar cases can be considered equivalent to a situation in which the outcome of the bargaining game corresponds to a one-stage game.

[6] In our setting, a difference is that the disagreement payoffs correspond to the relative amount of taxes paid.

3.2 Data

For each of the six French Water Agencies, we collect yearly data on tax payments and subsidies by user category, as well as on the composition of the six River Basin Committees, from 1987 to 2007.

Water users are paying taxes according to their contribution to water extraction and use, and effluent emissions. Taxes include the following categories: urban and industrial wastewater effluent emissions, agricultural point source emissions (livestock), nonpoint source emissions, residential and industrial water withdrawals and net consumption, and irrigation water abstraction.

Note that residential users pay emission and water consumption taxes not directly to the Water Agency, but through the local community's water utility. Local communities also pay taxes for municipal water use and emission, but this is in a large majority of cases a typically small proportion of taxes transferred by local communities to the Water Agency.

Subsidies granted by Water Agencies are mostly devoted to infrastructure building and operating costs of abatement by private agents or local communities. They include municipal wastewater treatment plants, wastewater networks, operational and technical assistance, refuse recycling for local communities; industrial pollution abatement plants, operational and technical assistance for industry; point- and nonpoint-source pollution abatement for agriculture; water resource management, restoration of aquatic areas, restoration of drinking water sources for ecosystems. Symmetrically to the fact that residential water users do not pay taxes directly, they do not receive direct subsidies, which are granted to local communities instead.

The proportion of subsidies received by each user category (agriculture, industry, residential users) is computed for each river basin and each multi-year intervention programme.[7]

[7] Subsidy figures from Water Agencies are detailed by final user but, from a non-budgetary point of view, there may be indirect beneficiaries to projects. For example, abatement projects for livestock farmers may be beneficial in terms of raw water quality to residential users ; extension of a water distribution network may benefit industrial plants within city bounds, etc. We acknowledge this can be a source of bias which cannot be corrected given available data, but from a strictly budgetary point of view, final beneficiaries from

Although emission and water-use tax rates as well as subsidy rates are defined over the period of five-year intervention programs for each Water Agency, the relative taxes and subsidies paid by each user category are not constant because of yearly applications for project funding, and because of yearly changes in the level of economic activity of water users (impacting tax revenues).

Regarding the number of representatives in River Basin Committees, we compute the proportion of each category of users (with a particular focus on agriculture and industry) with respect to the size of the entire committee, and with respect to the number of user representatives (agriculture, industry, tourism, fisheries, angling, energy producers, etc.), excluding in that case representatives of the administration not paying water taxes and not receiving subsidies. Note that for residential users, there are two possible types of representatives: from water consumers (consumer associations, etc.) and from local communities, the latter possibly representing other water users. This is also true for farmers, who are represented by specific professional members in the RBCs, but whose interests may also be represented by representatives of rural communities. We assume that this is the case for farmers, but it is not possible to single out industry representatives for agrofood and food processing on the one hand, and for other industries on the other. We therefore assume that industry representatives do not represent farmers' interests.

Regarding projects subsidized by Water Agencies and which concern ecosystem conservation, there are no corresponding tax payers in that case, and benefits can exist for more than one user category. However, it is reasonable to assume that local communities and therefore residential water users are the most important beneficiaries of these projects. We therefore affect natural resource and ecosystem conservation projects to local communities. Table 1 presents summary statistics for our sample.

[TABLE 1 ABOUT HERE]

There is a clear ranking of tax contributors with agriculture, industry and residential users in increasing order, which is also observed for subsidies from the Water Agency. However,

subsidy decisions are correctly identified.

ratios of subsidy over tax are fairly heterogeneous on average across user categories.

3.3 Structural Estimation

We consider here the special case of three categories of water users: as discussed above, in most water boards or agencies, water users paying taxes and receiving subsidies are residential users, industry and farmers. From the discussion above, it follows that a more detailed description of the equilibrium peaks α_i^* and the median α^* requires more detailed information on the parameters of the game. We illustrate Proposition 1 through a special case which will prove useful in the application to French Water Agency policy, where water users can reasonably be grouped into three major categories (local communities, industry, agriculture).

Consider then the case $k = 3$ and the simple majority game. From data presentation above, we let $\gamma_1 < \gamma_2 < \gamma_3$, with player 1 corresponding to agriculture, player 2 to industry, and player 3 to residential users. As before, we denote by x_i share of group i from the bargaining game. Since player 1 is the "cheapest", he is always in the winning coalition, therefore his share is:

$$x_1 = \begin{cases} \alpha\gamma_1 + (1-\alpha)(1-\gamma_2), \text{ with probability } \widehat{p}_1, \\ \gamma_1, \text{ with probability } 1-\widehat{p}_1. \end{cases}$$

Consider then player 2. It is included in the winning coalition by group 1 but not by group 3:

$$x_2 = \begin{cases} \alpha\gamma_2 + (1-\alpha)(1-\gamma_1), \text{ with probability } \widehat{p}_2, \\ \gamma_2, \text{ with probability } \widehat{p}_1, \\ \alpha\gamma_2, \text{ with probability } \widehat{p}_3. \end{cases}$$

Since player 3 is the "most expensive", it is invited as a coalition partner by neither group 1 nor group 2:

$$x_3 = \begin{cases} \alpha\gamma_3 + (1-\alpha)(1-\gamma_1) \text{ with probability } \widehat{p}_3, \\ \alpha\gamma_3 \text{ with probability } 1-\widehat{p}_3. \end{cases}$$

From the assumption on u_1 it follows that $V_1'(\alpha) < 0$ and therefore, $\alpha_1^* = 0$.

Results are summarized in Figure 1, and details are provided in Appendix 2.

[INSERT FIGURE 1 ABOUT HERE]

In the case of a Constant Relative Risk Aversion (CRRA) utility function with risk aversion parameter ρ,

$$u_i(x) = \begin{cases} \frac{x^{1-\rho_i}}{1-\rho_i} \text{ for } \rho_i > 0, \rho_i \neq 1, \\ \ln x \text{ for } \rho_i = 1, \end{cases} \quad \text{for } i = 1, 2, 3, \tag{15}$$

first-order conditions (25) and (26) (see Appendix 2) can be solved explicitly for α_2^* and α_3^*:

$$\alpha_2^* = \frac{\gamma_2 + \gamma_3}{\left(\frac{\widehat{p}_2}{\widehat{p}_3}\frac{\gamma_3}{\gamma_2}\right)^{\frac{1}{\rho_2}} \gamma_2 + \gamma_3} \tag{16}$$

and

$$\alpha_3^* = \frac{\gamma_3 + \gamma_2}{\left(\frac{\widehat{p}_3}{1-\widehat{p}_3}\frac{\gamma_2}{\gamma_3}\right)^{\frac{1}{\rho_3}} \gamma_3 + \gamma_2}. \tag{17}$$

Interestingly, since for CRRA utility functions $u_i'(0) = \infty$, the two extreme cases with $\alpha^* = 0$ (see Figure 1) disappear, i.e., at equilibrium a positive part of the budget is always shared according to the mechanical rule. We assume from now on that risk aversion parameters ρ are constant over time.

The system of budget share equations can be written, for water user category i, river basin j and time period t:

$$x_{1jt} = \gamma_{1jt} + \hat{p}_{1jt}(1 - \alpha_{jt}^*)(1 - \gamma_{1jt} - \gamma_{2jt}), \tag{18}$$

$$x_{2jt} = \hat{p}_{2jt}\left[\alpha_{jt}^*\gamma_{1jt} + (1 - \alpha_{jt}^*)(1 - \gamma_{1jt})\right] + \gamma_{2jt}\hat{p}_{1jt} + \alpha_{jt}^*\gamma_{2jt}\hat{p}_{3jt}, \tag{19}$$

$$x_{3jt} = \gamma_{3jt} + (1 - \alpha_{jt}^*)\left[\hat{p}_{3jt}(1 - \gamma_{1jt}) - \gamma_{3jt}\right], \tag{20}$$

where

$$\alpha_{jt}^* = \alpha_{2jt}^* = \frac{(\gamma_{2jt} + \gamma_{3jt})}{\gamma_{3jt} + \gamma_{2jt}\left(\frac{\hat{p}_{2jt}}{\hat{p}_{3jt}} \times \frac{\gamma_{3jt}}{\gamma_{2jt}}\right)^{1/\rho_{2j}}} \qquad \text{if } \frac{\hat{p}_{3jt}}{\hat{p}_{2jt}} < \frac{\gamma_{3jt}}{\gamma_{2jt}},$$

$$\alpha_{jt}^* = \alpha_{3jt}^* = \frac{\gamma_{3jt} + \gamma_{2jt}}{\left(\frac{\widehat{p}_{3jt}}{1-\widehat{p}_{3jt}}\frac{\gamma_{2jt}}{\gamma_{3jt}}\right)^{\frac{1}{\rho_{3j}}} \gamma_{3jt} + \gamma_{2jt}} \qquad \text{if } \frac{\hat{p}_{3jt}}{1 - \hat{p}_{3jt}} > \frac{\gamma_{3jt}}{\gamma_{2jt}},$$

and

$$\alpha^*_{jt} = 1 \qquad \text{if } \frac{\hat{p}_{3jt}}{1-\hat{p}_{3jt}} > \frac{\gamma_{3jt}}{\gamma_{2jt}} > \frac{\hat{p}_{3jt}}{\hat{p}_{2jt}}.$$

From Equation (18), it can be seen that for any value of α^*, user category 1 (agriculture) always gains from bargaining because $x_{1jt} - \gamma_{1jt} \geq 0$.

The structural model of bargaining consists of the system of non linear equations for subsidy shares, with probabilities p_{ijt}, tax shares γ_{ijt} and risk-aversion parameter ρ_{ij} on the right-hand side. Because probabilities (that a representative of category j is a proposer) are not observed and correspond to the subsidy internal committee, we assume that they are related to observed political representation of water users in the RBCs. More precisely, we specify a logit probability:

$$\begin{aligned} \hat{p}_{ijt} &= Prob(\text{user } i \text{ from river basin } j \text{ at time } t \text{ is the proposer}) \\ &= \frac{\exp\left[W_{ijt}(\beta_i - \beta_1)\right]}{\sum_{k=1}^{N} \exp\left[W_{kjt}(\beta_k - \beta_1)\right]},\ i = 1, \ldots, n, \end{aligned} \tag{21}$$

where, without loss of generality, category 1 is chosen as the reference.

The optimal parameter α^* in river basin j at time t equals α^*_2 if $\hat{p}_3/\hat{p}_2 < \gamma_3/\gamma_2$, equals α^*_3 if $\gamma_3/\gamma_2 < \hat{p}_3/(1-\hat{p}_3)$ and equals 1 if $\gamma_3/\gamma_2 \in [\hat{p}_3/(1-\hat{p}_3), p_3/p_2]$. By replacing probabilities $\hat{p}_j$ by their expression as functions of W_j, the optimal α is replaced in the structural equations for subsidy shares x_j depending on the three conditions above (which depend on observed γs and Ws).

Note that we do not have enough observations to estimate our model for each river basin (16 years for each). Therefore, parameter estimates (β, ρ) are to be considered average values over years and river basins.

The system of equations is estimated by GMM (Generalized Method of Moments), using γ_1 and W_2 as instruments. To achieve convergence, we only keep two equations for estimation because dependent variables (shares) sum to one. We arbitrarily drop the third equation (residential users), to focus on user categories agriculture and industry.

For some river basins and years, γ_1 is equal to zero because multiyear programmes did not have agricultural use or emission tax in their policies. To correct for this, we augment the set of explanatory variables with a dummy variable, equal to 1 if agricultural tax share

$\gamma_1 > 0$ and 0 otherwise. Moreover, for some observations $x_1 = 0$, not as a result of bargaining in RBCs, but because the water agency did not have a subsidy policy for agricultural projects. We include a dummy variable (see Moro and Sckokai, 1999) equal to 1 if $x_1 > 0$ and 0 otherwise when x_1 is an explanatory variable (in the equation for x_2), and we perform a preliminary Tobit estimation to check for the presence of a possible selection bias because of censored observations. Parameters associated with dummy variables as well as the parameter on selection correction are not significant, indicating that censored observations do not significantly affect parameter consistency.

If there are enough observations in all three regimes for α^*, then $\rho_i, i = 1, 2$ would be identified. However, in the data, $\gamma_3/\gamma_2 - W_3/W_2 = 0.8095/0.1799 - 0.4887/0.3625 = 3.1515$, implying that if $\hat{p}_3/\hat{p}_2$ is not too far from W_3/W_2, the number of observations such that $\alpha^* = \alpha_2^*$ would be far greater than the two other cases. We check during estimation that this is the case, which implies that parameter ρ_3 is not identified because α^* is almost always equal to α_2^*. Therefore, we consider only the case $\alpha_{jt}^* = \alpha_{2jt}^*$.

To avoid possible small-sample bias because of excessive over-identification, we consider only two instruments for each equation, which yields two over-identifying moment restrictions (5 moment conditions for 3 parameters).The variance-covariance matrix of parameter estimates is computed with a heteroskedasticity-consistent robust procedure, using river basin as a cluster variable to construct such matrix.

3.4 Estimation results

We consider several specifications of the structural model, to check for robustness along two directions. The first one concerns the relevant proportion of RBC representatives to construct vector W, namely, either the full committee or only water users as a subset of the former. Additionally, we consider two classification possibilities for representatives of rural communities, namely, either with agriculture or with other local communities. Estimation results are in Table 2, with various specifications from Model (A) to Model (F).

Parameter estimates are remarkably similar across model specifications, as far as β_2, β_3 and ρ are concerned, but also the average estimate of α, around 0.68. All estimates are significantly different from 0 at the 5 percent level. Regarding the specification tests, we compute the Hansen J-test of over-identifying restrictions. Associated p-values of the J-test are all above 5 percent, so that model specifications from (A) et (F) are not rejected. Finally, concerning the goodness-of-fit measures, determination coefficients are around 0.10 and 0.35 for the agricultural and industry share equation respectively.

Parameter estimates are used to compute the estimate of average α over river basins and years. We compute a Wald test for the assumption that $\alpha^* = 0$ (no predetermined part of budget to bargain upon) or $\alpha^* = 1$ (no bargaining), at the sample mean. The p-values of these test statistics are well below 0.05, so that the assumption of a single-stage game with full or no bargaining is strongly rejected, when α^* is evaluated at the sample mean.

[TABLE 2 ABOUT HERE]

We compare our GMM structural parameter estimates with reduced-form estimates. To ease comparison, the latter are computed under a model specification as close as possible to the structural model, i.e., with the same explanatory variables, and a two-step GMM estimator with exogenous variables as instruments in the corresponding equation. To have a benchmark from empirical analyses of similar settings in the literature, we consider the work of Kauppi and Widgren (2004).

In Kauppi and Widgren (2004), two alternative explanations of the distribution of the European Union (EU) budget are contrasted, with players being the state members of the European Union. A possible explanation called the *"needs view"* postulates that members' allocations are determined by a principle of solidarity which can be evaluated in several ways. Given that the bulk of budget spending is devoted to agriculture and less-favoured regions, Kauppi and Widgren measure the needs of EU countries by the weight of their agricultural production and their relative income levels. A second explanation called the *"power politics view"* considers the problem, as we do, as a *divide-the-dollar* bargaining game where the power of the player is exclusively described by his voting weight. Their results indicate that at least 60% of the budget expenditures can be attributed to selfish power politics and the remaining 40% to the declared benevolent budget policies. However, when they apply specific voting power measures that allow for correlated preferences and cooperative voting patterns between member states, their estimates indicate that the power politics view explains as much as 90% of the budget shares.

Kauppi and Widgren's bargaining solution is borrowed from *cooperative game theory*, in contrast to ours which is based on a non-cooperative bargaining game. Kauppi and Widgren's power measure is entirely based upon the voting weight, while ours also depends on the *proposal power*.

In our case, the political view of Kauppi and Widgren can be captured by the proposition of members for each category in RBCs (W). However, for the needs view, we consider instead the share of tax payments γ_i because of the principle "water pays for water" applied by Water Agencies, and also the fact that subsidies aim at helping water users reduce their tax burden paid to water Agencies. We therefore consider only W and γ as explanatory variables. This also has the advantage of matching exactly variables used in the structural model.

We perform a regression analysis of the relative subsidies received by two out of the three main water users (agriculture and industry, because these shares sum to 1), as a function of relative representation in RBC and/or tax shares of each user category.

The system of reduced-form equations is the following:

$$x_{jit} = \beta_0 + \beta_{1j} W_{jit} + \beta_{2k} W_{kit} + \beta_{3j}\gamma_{jit} + \beta_{4j}\gamma_{kit} + \alpha_{ij} + \varepsilon_{ijt}, \qquad (22)$$

$$i = 1, 2, \ldots, 6;\ t = 1, 2, \ldots, T;\ j, k = 1, 2 \text{ (agriculture, industry)},$$

where x_{jit} is the share of total subsidies received by the user category j (agriculture, industry) by Water Agency i at time t, W_{jit} and W_{kit} are the proportions of representatives in the River Basin Committee for user category j and k respectively, and γ_{jit} is the share of tax payments to the Water Agency paid by user category j. Unobserved heterogeneity specific to Water Agency i and to the user category is captured by the individual effect α_{ij}, and ε_{ijt} is an i.i.d. random disturbance. We do not consider a fixed-effect estimation method, as the number of time periods is large (16), and possible correlation between unobserved individual effects α_{ij} and explanatory variables would lead to rejection of the model specification with the Hansen test anyway. The same procedure as in the structural model is used to control for censored observations with $x_1 = 0$ (see above).

Because a significant proportion of RBC members are not likely to have a significant role in the discussions over the distribution of subsidies, we consider only the proportion of (agriculture, industry) representatives with respect to the total number of user representatives in the RBC, which corresponds to specification (F) of the structural model.

Table 3 presents estimation results by GMM of the reduced-form model, with two special cases: Model I with only γ as regressors, and Model II with only W as explanatory variables, corresponding to the needs view and the political view respectively, as in Kauppi and Widgren (2004). According to the Hansen over-identifying restriction test statistic, the specification of all three models is not rejected.

In the complete specification of Model III, only the relative tax share of industry γ_2 is significant and has the expected sign (respectively negative and positive in the equation for agriculture and industry). Model I ("needs view") performs well with tax shares γ_1 and γ_2 significantly different from 0, whereas for Model II, variables for political representation W_1 and W_2 are significant in three cases out of four.

Regarding goodness of fit, our structural model with the same number of parameters (β_2, β_3 and ρ) as Model I has a slightly lower coefficient R^2 than Model I or Model III. It is not possible to test directly the structural bargaining model against a reduced-form model, because models are not nested (namely, the structural model is not a special case of a reduced-form model with a particular value of parameters). For this reason, we consider a non-nested test which has been proposed by Hall and Pelletier (2011). This test follows the approach proposed by Smith (1992) and Rivers and Vuong (2002) but it is specially designed for GMM estimation. The test statistic is not significantly different from 0 if the pair of models is equivalent, and allows one to conclude in favour of the structural model if it is negative and significant. Because alternative specifications of the structural model produce very similar non-nested test outcomes, we select Model (F) from structural estimation to compare with reduced-form estimation results. Results of the non-nested testing procedure in Table 3 indicate that models are observationally equivalent at the 5 percent level, and that the structural model would be preferred to reduced-form Model III at the 10 percent level.

We therefore conclude that our structural model performs well in predicting relative subsidy shares, with a limited number of parameters and restrictions on the relationship between x and W imposed by the bargaining model.

[TABLE 3 ABOUT HERE]

Finally, from the structural model parameter estimates, we compute estimated probabilities that a representative of a particular category is chosen as a proposer ($\hat{p}$). From Table 4 reporting average proportions of representatives (W) together with estimated probabilities, one can see that average $\hat{p}$ and W are close for industry. However, the probability estimate is about twice the average proportion W for farmers, while it is lower by about one-third for local communities. We therefore identify an additional factor for the systematic excess ratio of subsidy over tax for farmers, due to the nature of the bargaining process. Farmers receive a larger share of subsidies than their relative contribution to total taxes, not only because they are often well represented in RBSs, but also because the estimated probability that a farmer representative is chosen as a proposer is higher.

[TABLE 4 ABOUT HERE]

4 Discussion

The bargaining model presented in this paper draws upon Baron and Ferejohn (1989) and is applied to represent coalition formation and sequential negotiation over an environmental budget in the case of water boards. With the special case of three water user categories and CRRA preferences of representatives in River Basin Committees, we provide a theoretical explanation for systematic net gains from bargaining for some user categories. Beside the role of political representation in River Basin Committees that may be distorted compared with respect to tax contributions to the total budget, the nature of the negotiation process is also shown to have a major role. First, some representatives of water user categories may be easier to invite in a coalition when negotiating over budget distribution because of their lower contribution in terms of taxes. Being more often in winning coalitions with other representatives, these categories benefit from relatively higher subsidy-tax ratios. Second, the bargaining model contains two stages, i.e., negotiation over a fixed part of the budget proportional to tax contributions of each user category, and then negotiation over the distribution of the residual budget.

In our empirical application to French Water Agencies over the period 1987-2007, the agricultural sector benefits from a systematically positive difference between subsidies and taxes, while for industry and residential users, such difference depends in a nontrivial way of user representation and the probability to be selected as a proposer of a budget distribution. We perform a structural estimation of the bargaining model under assumptions regarding players' preferences, the distribution of representative power over water users, and the structure of the bargaining game. Several specification tests confirm that our structural model is not rejected in favour of reduced-form models with either a political or a "needs" view as the only determinant of budget shares. Compared with reduced-form estimation, our structural model performs well in terms of parameter significance and goodness-of-fit. Moreover, the restriction that the two-stage game reduces to a single-stage game, when either full or no bargaining is taking place, is also rejected.

Our results can be used to provide a better understanding of the nature of negotiation processes in water boards and its expected impact on budget distribution issues. In particular, policy makers willing to reduce the asymmetry between net contributions of water users may either reform voting rules and user representation in committees, or modify economic instruments such as taxes. In the first case, a possibility would be to consider a one-stage game which, based on the discussion above and Figure 1 in the case of three water user categories, would imply either $\alpha^* = 0$ (full bargaining) or $\alpha^* = 1$ (no bargaining and subsidy shares proportional to relative tax payments). The bias towards a particular user category obviously disappears if $\alpha^* = 1$. However, if a two-stage process is maintained, such an outcome of the game would depend, as shown in Section 3, on the ratio of relative tax payments γ_3/γ_2 as well as on the probability that some user categories are selected as proposers, which may be different from the relative frequency of representatives in the committee. In the second case, the bias towards agriculture in particular (player 1) coud obviously be limited if γ_1 is increased. However, even if the cost of "buying" this category for joining a coalition would increase as a result, this is not enough to modify the outcome of coalition formation.

Our bargaining model provides a simplified representation of negotiation over budget in river basin committees, with reasonable performance given data limitations. Deeper investigation into coalition formation and bargaining in committees, using detailed proceedings of committee meetings for a given river basin, is a possible extension of the present analysis. In addition, other environmental or land planning policies could be considered, when a similar bargaining process over a budget among stakeholder representatives is present (see for example Proost and Zaporozhets, 2013 on transportation issues).

Appendix 1. Proof of Proposition 1.

Taking derivatives of V with respect to α one gets:

$$\begin{aligned} V_i'(\alpha) &= -\widehat{p}_i u_i' \left(\gamma_i + (1-\alpha) \sum_{j\in N\setminus(S_i\cup\{i\})} \gamma_j\right) \sum_{j\in N\setminus(S_i\cup\{i\})} \gamma_j \\ &+ (1-\widehat{p}_i - P_i)\, u_i'(\alpha\gamma_i)\gamma_i. \end{aligned} \tag{23}$$

and

$$\begin{aligned} V_i''(\alpha) &= \widehat{p}_i u_i'' \left(\gamma_i + (1-\alpha) \sum_{j\in N\setminus(S_i\cup\{i\})} \gamma_j\right) \left(\sum_{j\in N\setminus(S_i\cup\{i\})} \gamma_j\right)^2 \\ &+ (1-\widehat{p}_i - P_i)\, u_i''(\alpha\gamma_i)\,(\gamma_i)^2. \end{aligned} \tag{24}$$

Since $u_i''(\cdot) < 0$ it follows from (24) that $V_i''(\alpha) \leq 0$.

From (23) it follows that:

$$V_i'(1) = u_i'(\gamma_i)\left[(1-\widehat{p}_i - P_i)\,\gamma_i - \widehat{p}_i \sum_{j\in N\setminus(S^i\cup\{i\})} \gamma_j\right],$$

therefore for $\gamma_i \geq \overline{\gamma}_i = \frac{\widehat{p}_i \sum_{j\in N\setminus(S_i\cup\{i\})} \gamma_j}{1-\widehat{p}_i - P_i}$ the function $V_i'(1) \geq 0$, and for $\gamma_i \leq \overline{\gamma}_i$ the opposite inequality holds true.

The derivative of V at $\alpha = 0$ is:

$$V_i'(0) = -\widehat{p}_i u_i' \left(\sum_{j\in N\setminus S_i} \gamma_j\right) \sum_{j\in N\setminus(S_i\cup\{i\})} \gamma_j + (1-\widehat{p}_i - P_i) u_i'(0)\gamma_i.$$

One can check that: $V_i'(0) \leq 0$ if and only if $\gamma_i \leq \underline{\gamma}_i$, where $\underline{\gamma}_i$ satisfies (14).

Since $u_i'' \leq 0$ we can deduce that $u_i'(0) \geq u_i'\left(\sum_{j\in N\setminus S^i} \gamma_j\right)$. Substituting this into (14) we prove that $\underline{\gamma}_i \leq \overline{\gamma}_i$.

Summing up, for $0 \leq \gamma_i \leq \underline{\gamma}_i$ the function $V_i(\alpha)$ is decreasing on the whole interval $[0,1]$, for $\gamma_i \geq \overline{\gamma}_i$ it is increasing on the whole interval, and for $\underline{\gamma} < \gamma_i < \overline{\gamma}_i$ it has unique maximum on the interval $[0,1]$.

Appendix 2. Derivation of optimal α^*.

From Proposition 1, the thresholds for group 2 are:

$$\overline{\gamma}_2 = \frac{\widehat{p}_2\gamma_3}{\widehat{p}_3} \text{ and}$$

$$\underline{\gamma}_2 = \frac{\widehat{p}_2\gamma_3 u_2'(\gamma_2+\gamma_3)}{\widehat{p}_3 u_2'(0)}.$$

Therefore, the behavior of player 2 can be described as follows:

- for $\frac{\gamma_3}{\gamma_2} < \frac{\widehat{p}_3}{\widehat{p}_2}$, function $V_2(\alpha)$ increases on the whole interval $[0,1]$ and therefore $\alpha_2^* = 1$;

- for $\frac{\widehat{p}_3}{\widehat{p}_2} < \frac{\gamma_3}{\gamma_2} < \frac{\widehat{p}_3}{\widehat{p}_2}\frac{u_2'(0)}{u_2'(\gamma_2+\gamma_3)}$, function $V_2(\alpha)$ has an inferior maximum α_2^* on $[0,1]$ which is defined from the equality $V_2'(\alpha) = 0$, that is,

$$-\widehat{p}_2 u_2'(\alpha\gamma_2 + (1-\alpha)(1-\gamma_1))\gamma_3 + \widehat{p}_3 u_2'(\alpha\gamma_2)\gamma_2 = 0; \tag{25}$$

- for $\frac{\gamma_3}{\gamma_2} > \frac{\widehat{p}_3}{\widehat{p}_2}\frac{u_2'(0)}{u_2'(\gamma_2+\gamma_3)}$, function $V_2(\alpha)$ is decreasing on the whole interval $[0,1]$ and therefore $\alpha_2^* = 0$.

In a similar way, the thresholds on the tax share for player 3 can be expressed as follows:

$$\overline{\gamma}_3 = \frac{\widehat{p}_3\gamma_2}{1-\widehat{p}_3} \text{ and}$$

$$\underline{\gamma}_3 = \frac{\widehat{p}_3\gamma_2 u_3'(\gamma_2+\gamma_3)}{(1-\widehat{p}_3)u_3'(0)}.$$

The behavior of player 3 can be summarized as:

- for $\frac{\gamma_3}{\gamma_2} < \frac{\widehat{p}_3}{1-\widehat{p}_3}\frac{u_3'(\gamma_2+\gamma_3)}{u_3'(0)}$ function $V_3(\alpha)$ is decreasing on the whole interval $[0,1]$ and therefore $\alpha_3^* = 0$;

- for $\frac{\widehat{p}_3}{1-\widehat{p}_3}\frac{u_3'(\gamma_2+\gamma_3)}{u_3'(0)} < \frac{\gamma_3}{\gamma_2} < \frac{\widehat{p}_3}{1-\widehat{p}_3}$, function $V_3(\alpha)$ has an inferior maximum α_3^* on $[0,1]$ and it is defined from $V_3'(\alpha) = 0$:

$$-\widehat{p}_3 u_3'(\alpha\gamma_3 + (1-\alpha)(1-\gamma_1))\gamma_2 + (1-\widehat{p}_3)u_3'(\alpha\gamma_3)\gamma_3 = 0; \tag{26}$$

- for $\frac{\gamma_3}{\gamma_2} > \frac{\widehat{p}_3}{1-\widehat{p}_3}$, function $V_3(\alpha)$ is increasing on the whole interval $[0,1]$ and therefore $\alpha_3^* = 1$.

We can identify the median voter: it is either player 2 if $\frac{\gamma_3}{\gamma_2} > \frac{\widehat{p}_3}{\widehat{p}_2}$ or player 3 if the opposite inequality holds.

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Table 1: Descriptive statistics

Variable	Mean	Std. deviation	Min.	Max.
Taxes paid by agriculture (percent)	1.0105	1.0098	0.0000	3.8789
Taxes paid by industry (percent)	18.3984	8.5750	8.1221	49.9213
Taxes paid by residential users (percent)	80.5910	8.4402	50.0786	90.4670
Subsidies received by agriculture (percent)	6.8219	7.2635	0.0000	35.6239
Subsidies received by industry (percent)	15.5609	12.2956	1.7166	47.8448
Subsidies received by local communities	77.6110	11.3860	50.8769	97.8370
Agricultural representatives (percent)	14.4975	3.3121	7.6923	21.21.21
Industry representatives (percent)	35.2852	5.2392	25.0000	42.5000
Residential user representatives (percent)	50.2172	4.8662	40.4762	63.8888

Notes. 96 observations. Period 1987-2007, six Water Agencies (Adour-Garonne, Artois-Picardie, Loire-Bretagne, Rhin-Meuse, Rhône-Méditerranée-Corse and Seine-Normandie).

Table 2: GMM estimation of structural equations

	(A)	(B)	(C)	(D)	(E)	(F)
γ	Lagged	Lagged	Lagged	Lagged	Current	Current
W from	Full RBC	Users only	Full RBC	Users only	Full RBC	Users only
Rural comm. with agriculture	Yes	Yes	No	No	Yes	Yes
β_2	1.4930***	1.2314***	1.4623***	1.2013***	1.1659***	1.4313***
	(0.4733)	(0.3769)	(0.4625)	(0.3643)	(0.3061)	(0.4058)
β_3	2.2434***	2.4813***	2.1854***	2.4100***	2.8955***	2.6345***
	(0.4174)	(0.4724)	(0.4044)	(0.4417)	(0.5129)	(0.4433)
ρ	0.6787***	0.7084***	0.6841***	0.7077***	0.6406**	0.5722**
	(0.2240)	(0.2130)	(0.2256)	(0.2079)	(0.2760)	(0.2759)
α	0.6789***	0.6781***	0.6804***	0.6775***	0.6798***	0.6783***
	(0.1689)	(0.1590)	(0.1684)	(0.1603)	(0.1856)	(0.1966)
J-test $\chi^2(2)$	1.0117	1.0639	1.0067	1.0327	0.9871	0.8946
p-value	(0.6030)	(0.5875)	(0.6045)	(0.5967)	(0.6104)	(0.6394)
R^2 for x_1	0.1054	0.1083	0.1057	0.1082	0.0957	0.0966
R^2 for x_2	0.3743	0.3565	0.3754	0.3576	0.3587	0.3814
Obs.	90	90	90	90	96	96

Estimation method: nonlinear two-step GMM. Standard errors in parentheses are estimated from a heteroskedasticity-consistent robust variance-covariance matrix.*, ** and *** respectively denote parameter significance at 10, 5 and 1 percent level. Parameter α is estimated in a second stage from GMM estimates, and at the sample mean.

Tax shares γ are lagged in Models (A) to (D) ; W is computed from all River Basin Committee members in Models (A), (C) and (E), and from water users ony in Models (B), (D) and (F) ; rural communities are grouped with agricultural representatives in Models (A), (B), (E) and (F), and grouped with other municipalities in Models (C) and (D).

Table 3: GMM estimation of reduced-form equations

	Model I		Model II		Model III	
Dep. variable	x_1	x_2	x_1	x_2	x_1	x_2
Intercept	0.0712***	0.0032	-0.3198**	0.3940**	-0.0561	0.0038
	(0.0139)	(0.0202)	(0.1374)	(0.1942)	(0.0816)	(0.0822)
γ_1	1.7747**	-1.8911**			1.2380	-1.1170
	(0.7998)	(0.7422)			(1.4106)	(1.0380)
γ_2	-0.1394***	0.9618***			-0.1165***	0.9163***
	(0.0413)	(0.0894)			(0.0421)	(0.0946)
W_1			1.7603***	-1.9132**	0.4144	-0.1866
			(0.6023)	(0.7795)	(0.3491)	(0.3579)
W_2			0.3634**	0.1276	0.1843	0.0780
			(0.1688)	(0.2752)	(0.1737)	(0.1640)
R^2	0.1417	0.5018	0.1070	0.0615	0.1856	0.5041
Hansen test	$\chi^2(2) = 2.1580$	(0.3399)	$\chi^2(2) = 4.1957$	(0.1227)	$\chi^2(2) =4.0410$	(0.1326)
τ statistic	-0.0210	(0.5184)	-1.4035	(0.1604)	-1.7704	(0.0767)

96 observations. Estimation method: Linear Generalized Method of Moments (GMM). Standard errors (in parentheses) are estimated from a heteroskedasticity-consistent robust variance-covariance matrix.*, ** and *** respectively denote parameter significance at 10, 5 and 1 percent level. Instruments for Model I and Model II equations: $(1, \gamma_1, \gamma_2, w_2)$. Instruments for Model III equations : $(\gamma_1, w_2, \gamma_2, w_1, w_1 \times \gamma_2, \gamma_1 \times \gamma_2)$. τ statistic is the non-nested test statistic for $H_0 : M_S = M_R$, with p-value in parentheses (M_S and M_R are structural and reduced- form models respectively).

Table 4: Interest-group representation in River Basin Committees and estimated probabilities to act as proposer

Variable	Mean	Std. Deviation
$\hat{p}_1$	0.2775	0.0045
$\hat{p}_2$	0.3930	0.0144
$\hat{p}_3$	0.3294	0.0102
W_1	0.1487	0.0336
W_2	0.3625	0.0551
W_3	0.4887	0.0509

96 observations. Estimated probabilities are assumed logit.

Figure 1. The different cases with three players