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

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Abstract In decentralized water management with earmarked budgets financed by user taxes and distributed back in the form of subsidies, net gains are often heterogeneous across user categories. This paper explores the role of negotiation over budget allocation and coalition formation in water boards, to provide an explanation for such user-specific gaps between tax payments and subsidies. We propose a bargaining model to represent the sequential nature of the negotiation process in water districts, in which stakeholder representatives may bargain upon a fraction of the budget only. The structural model of budget shares estimated from the data on French Water Agencies performs well as compared with reduced-form estimation. Empirical results confirm the two-stage bargaining process and provide evidence for systematic net gains from the system for agricultural water users.

Keywords Water policy · Political economy · Structural estimation · Bargaining

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 et al. 2010; Lessmann et al. 2015), management of

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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. Moreover, according to the Water Framework Directive of the European Union, all member states are expected to organize the transition to a decentralized and participatory governance for water management (Watson and Howe 2006).

More precisely, in such institutional setting, a budget raised from water use charges or emission taxes is redistributed between resource users, in the form of 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 almost always favoured by the system.

When confronting the reality of participatory and decentralized water management with the imbalance between taxes and subsidies, we are faced with the following empirical puzzle: Why is decentralized bargaining over user-financed environmental budgets producing such heterogeneous net gains across users, when those users are included in the governance of water management? The objective of the paper is to provide a possible answer to this puzzle, based on a simplified representation of the bargaining and coalition formation process within committees. An immediate justification for such imbalance is that water users do not have the same ability to control environmental impacts from their activity, so that their needs in terms of policy are different. This explanation based on needs is consistent with the river basin solidarity principle but it may not be the only one. An additional factor, which can exacerbate or compensate the imbalance between taxes and subsidies among water users, can be found in the participatory process associated with decentralized water management. More precisely, the observed discrepancies between relative tax payments and subsidies can be explained by the relative weights of water user categories in committees, but also possibly by the nature of the negotiation process within committees.
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 of such bargaining model is that water management decisions 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 Widgrén (2004).

Our stylized bargaining model can only be estimated as a structural econometric model because of a series of simplifying assumptions on agents’ preferences and the bargaining process in river basin committees. We should emphasize that the model provides a possible explanation for the empirical puzzle of tax-subsidy gaps under participatory decentralized water management, but this explanation is not unique and may not be the best one to predict observed outcomes. Other causal mechanisms are likely to be relevant and, given data limitations and necessary restrictive specifications on agents’ preferences, it is only possible to test whether our model performs at least as well as reduced-form estimation.

The outline of the paper is as follows. In Sect. 2, we present the bargaining model in the general case of a water board (or river basin committee) with water user representatives. We consider in Sect. 3 the French Water Agencies and River Basin Committees as a particularly relevant application of the special case of three water user categories. In this section we briefly discuss the French water policy and present the data, before proceeding to structural model estimation and the comparison with a reduced-form system of equations. 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 (2000), 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 to 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.\(^1\)

### 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 \(\gamma_i\) the fraction of total taxes paid by the \(i\)th category of users:

\[
\gamma_i = \frac{t_i}{\sum_{j=1}^{k} t_j},
\]

(1)

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

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\(^1\) Several empirical analyses of the BF bargaining model have been conducted, including Knight (2004, 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.
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, as reflected by their utility function $u_i = u_i(x_i),$ $i = 1, 2, \ldots, k.$ 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 $\beta_{ij}$ to user category $i$, $i = 1, \ldots, k$, 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 $x = (x_1, \ldots, x_k)$ the utility of player $j$, $j = k + 1, \ldots, n$, is

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

(2)

where $u_j$ is a twice continuously differentiable function such that $u'_j > 0$ and $u''_j < 0$. 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 \[
\left\lfloor \frac{\sum_{i=1}^k q_i}{2} + (n-k) \right\rfloor \quad \text{and} \quad \left( \sum_{i=1}^k q_i \right) + (n-k).\] Therefore, our framework allows for a wide range of voting mechanisms. When $Q = \left\lfloor \frac{\sum_{i=1}^k q_i}{2} + (n-k) \right\rfloor$, 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 $\mathcal{W} (\mathcal{W}_n)$ the set of winning (minimal winning) coalitions.\(^3\)

The distribution of proposal powers is represented by the vector $p = (p_1, p_2, \ldots, p_n)$ such that $p_i \geq 0$ for all $i = 1, \ldots, n$, 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 probability to act as a proposer, $p_i$, is likely to reflect the proportion of representatives for category $i$ and therefore the relative voting weight $w_i = q_i/n$. We consider however a more general case and we do not impose $p_i$ and $w_i$ to be equal, as other factors than $q_i$ may influence voting weights.

The game has two stages. The first stage is a BD bargaining game on the fraction, denoted $\alpha$, of the budget distributed proportionally to tax payments. This is a sequential game with a possibly infinite number of rounds and each player is informed of all options. 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 no proposal is ever accepted, the players decide $\gamma$.

If $\alpha = 1$ is selected, the game ends after the first stage and the whole budget is distributed according to $\gamma$. 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

\(^2\) For any real number $x$, $\lfloor x \rfloor$ denotes the smallest integer greater than $x$.

\(^3\) 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.
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 $\gamma$ 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.

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 $\sum_{i=1}^{k} x_{ij} = (1 - \alpha)$.

We denote by $S_\alpha$ 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 $\gamma$ 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

$$ u_l (\alpha \gamma + x_j) \geq u_l (\gamma). $$

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:

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

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

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

We also denote by $x^*_j(\alpha)$ for $j = 1, \ldots, n$ 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 $j$, $j = k + 1, \ldots, n$ acts in favour of a single user group. Letting $M_i (m_i)$ denote the group (the number) of representatives in the set $\{k + 1, \ldots, n\}$ 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

$$ x_i \geq \gamma_i (1 - \alpha). $$

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 $\{1, 2, \ldots, k\}$ 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:

$$ \hat{p}_i = p_i + \sum_{j \in M_i} p_j. $$

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

\footnote{The component $x_{ij}$ is the share of the budget offered to player $i$ by proposer $j$.}
We have

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

(8)

and therefore,

\[ C(\alpha, j) = (1 - \alpha) \left( 1 - \min_{S \cup \{j\} \in W_m} \sum_{i \in S \setminus \{j\}} \gamma_i \right). \]  

(9)

Equivalently in this case:

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

(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 \( \gamma_i \).

### 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 \( x_{ij}^* (\alpha) \) for all \( j, j = 1, \ldots, n \). In the first stage of the game, each player \( i \) views the choice of \( \alpha \) 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:

\[ \sum_{j=1}^{n} p_j u_i \left( \alpha \gamma_i + x_{ij}^* (\alpha) \right). \]  

(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:

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

We obtain that:

\[ V_i (\alpha) = \hat{P}_i u_i \left( \gamma_i + (1 - \alpha) \sum_{j \in N \setminus (S_i \cup \{i\})} \gamma_j \right) + P_i u_i (\gamma_i) + (1 - \hat{P}_i - P_i) u_i (\alpha \gamma_i). \]  

(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 \( \alpha_i^* \) 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 $\alpha^*$ of the vector $(\alpha^*_1, \ldots, \alpha^*_n)$.\footnote{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.}

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 $i$, $i = 1, \ldots, k$.

Moreover, there exist threshold values $\gamma^+_i$ and $\gamma^-_i$ such that $0 \leq \gamma^-_i < \gamma^+_i$ and:

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

(ii) if $\gamma^-_i < \gamma_i < \gamma^+_i$ $V_i(\alpha)$ has a unique maximum on the interval $(0, 1)$ and it is defined from the equation $V'_i(\alpha) = 0$;

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

**Proof** see Appendix 1.

Part (i) of Proposition 1 states that any player $i$ with relatively low $\gamma_i$, i.e., with $\gamma_i$ below $\gamma^+_i$, 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., $\gamma_i$. Being a “cheap” coalitional partner, he is included in any coalition when he is not a proposer receiving an offer equal to $\gamma_i$. When he is a proposer he gets strictly more than $\gamma_i$.

On the contrary, part (iii) of the proposition states that any player $i$ with relatively high $\gamma_i$, i.e., with $\gamma_i$ above $\gamma^-_i$, 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 $\gamma_i$, i.e., with $\gamma_i$ in between $\gamma^-_i$ and $\gamma^+_i$, would like to bargain upon some part of the budget as his $\alpha^*_i \in (0, 1)$.

### 3 Application

In this section we apply 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. An important assumption on the number of users allows us to obtain closed-form solutions from Proposition 1, which is useful and relevant for 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% of members for local communities, 40% for user representatives, and 20% 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 \( \alpha \) 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.⁷ First, it is reasonable to assume that members of RBCs prefer to avoid sharp changes in budget allocation one year to the next.⁸

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 (see footnote 7) 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. We assume that this proportion of the budget is related to (relative) tax payments of each user category. Unit tax rates paid by users are decided upon by River Basin Committees in advance for the full multi-year programme and are not renegotiated until the next programme. Consequently, tax shares can in principle be anticipated, but with a degree of accuracy directly depending upon the variability of future economic activity of water users.

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.

### 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, livestock-based emissions, residential and industrial water withdrawals and net consumption, and irrigation water abstraction.

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

⁷ This evidence is provided by interviews conducted by the authors with the deputy-CEO of the Adour-Garonne water agency on April 24, 2012, officials of the same Agency’s economic division, and members of the Adour-Garonne RBC on April 1, 2011.

⁸ According to the representative of industrial water users, Mr. Yves Casenove, “it is only with a global evaluation of subsidies and taxes that an objective comparison across user categories can be achieved. Such procedure has no other goal but to make sure the distribution of the budget is organized within reasonable bounds, in order to make progress in the concertation” (Adour-Garonne River Basin Committee meeting, July 4, 2011, Toulouse).
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.\(^9\)

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, local communities and therefore residential water users are the most important beneficiaries of these projects (CGDD 2012). We therefore affect natural resource and ecosystem conservation projects to local communities. Table 1 presents summary statistics for our sample.

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

\(^9\) 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 subsidy decisions are correctly identified.
Table 1  Descriptive statistics

| Variable (%)          | Mean    | SD       | Min.   | Max.    |
|-----------------------|---------|----------|--------|---------|
| Taxes paid by agriculture | 1.0105  | 1.0098   | 0.0000 | 3.8789  |
| Taxes paid by industry   | 18.3984 | 8.5750   | 8.1221 | 49.9213 |
| Taxes paid by residential users | 80.5910 | 8.4402   | 50.0786| 90.4670 |
| Subsidies received by agriculture | 6.8219  | 7.2635   | 0.0000 | 35.6239 |
| Subsidies received by industry    | 15.5609 | 12.2956  | 1.7166 | 47.8448 |
| Subsidies received by local communities | 77.6110 | 11.3860  | 50.8769| 97.8370 |
| Agricultural representatives | 14.4975 | 3.3121   | 7.6923 | 21.2121 |
| Industry representatives    | 35.2852 | 5.2392   | 25.0000| 42.5000 |
| Residential user representatives | 50.2172 | 4.8662   | 40.4762| 63.8888 |

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

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 $\alpha_i^*$ and the median $\alpha^*$ 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 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:

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

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

$$x_2 = \begin{cases} \frac{\alpha \gamma_2 + (1 - \alpha) (1 - \gamma_1)}{\gamma_2}, & \text{with probability } \hat{p}_2, \\ \alpha \gamma_3, & \text{with probability } \hat{p}_1, \\ \alpha \gamma_3, & \text{with probability } \hat{p}_3. \end{cases}$$

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

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

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

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

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

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first-order conditions (25) and (26) (see Appendix 2) can be solved explicitly for $\alpha^*_2$ and $\alpha^*_3$:

$$\alpha^*_2 = \frac{\gamma_2 + \gamma_3}{\hat{p}_3} \frac{1}{\hat{p}_2} \gamma_2 + \gamma_3$$

and

$$\alpha^*_3 = \frac{\gamma_3 + \gamma_2}{\hat{p}_3} \frac{1}{\hat{p}_2} \gamma_3 + \gamma_2$$

Interestingly, since for CRRA utility functions $u'_i(0) = \infty$, the two extreme cases with $\alpha^* = 0$ (see Fig. 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 $\rho_i$ are constant over time.

Omitting river basin and time indexes for the sake of clarity, the system of budget share equations can be written, for water user category $i$,

$$x_1 = \gamma_1 + \hat{p}_1(1 - \alpha^*)(1 - \gamma_1 - \gamma_2),$$

$$x_2 = \hat{p}_2 [\alpha^* \gamma_1 + (1 - \alpha^*)(1 - \gamma_1)] + \gamma_2 \hat{p}_1 + \alpha^* \gamma_2 \hat{p}_3,$$

$$x_3 = \gamma_3 + (1 - \alpha^*) \left[ \hat{p}_3(1 - \gamma_1) - \gamma_3 \right],$$

where

$$\alpha^* = \alpha^*_2 = \frac{(\gamma_2 + \gamma_3)}{\gamma_3 + \gamma_2} \frac{1}{\hat{p}_2} \frac{\hat{p}_2 \gamma_3}{\gamma_3 \gamma_2} \frac{1}{\hat{p}_2} \gamma_2 + \gamma_3$$

if $\frac{\hat{p}_3}{\hat{p}_2} < \frac{\gamma_3}{\gamma_2}$,

$$\alpha^* = \alpha^*_3 = \frac{(\gamma_3 + \gamma_2)}{\gamma_3 + \gamma_2} \frac{1}{\hat{p}_3} \frac{1 - \hat{p}_3}{\gamma_3 \gamma_2} \gamma_3 + \gamma_2$$

if $\frac{\hat{p}_3}{\hat{p}_2} > \frac{\gamma_3}{\gamma_2}$,

and

$$\alpha^* = 1 \text{ if } \frac{\hat{p}_3}{1 - \hat{p}_3} > \frac{\gamma_3}{\gamma_2} \text{ and } \frac{\hat{p}_3}{\hat{p}_2}.$$
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:

\[
\hat{p}_{ijt} = \text{Prob}(\text{user } i \text{ from river basin } j \text{ at time } t \text{ is the proposer}) \nonumber
\]

\[
= \frac{\exp[w_{ijt}(\beta_i - \beta_1)]}{\sum_{k=1}^{N} \exp[w_{kjt}(\beta_k - \beta_1)]}, \quad i = 1, \ldots, n, \quad (21)
\]

where \( w_i = q_i/n \) is the observed voting weight and, without loss of generality, category 1 is chosen as the reference.

The optimal parameter \( \alpha^* \) in river basin \( j \) at time \( t \) equals \( \alpha^*_2 \) if \( \hat{p}_3/\hat{p}_2 < \gamma_3/\gamma_2 \), equals \( \alpha^*_2 \) 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 \( \alpha \) is replaced in the structural equations for subsidy shares \( x_j \) depending on the three conditions above (which depend on observed \( \gamma_s \) and \( w_s \)).

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

The CRRA specification for all agents is a necessary restriction to obtain a closed-form solution, and it is difficult to evaluate whether departures from this assumption would lead to significant differences in outcome prediction. In any case, the robustness of model predictions is partly relying on the quality of the approximation by the CRRA function of the “true” utility function locally, around the level of net agent’s payoff. Imposing parameters \( (\beta, \rho) \) to be the same is a different matter, related to the number of degrees of freedom, and one needs to be cautious about the interpretation of results “on average” when imposing homogeneous parameters across agents and river basins. In this case, model predictions are likely to be affected significantly if deviations from uniform parameter values are correlated with observed variables such as relative tax shares or voting weights.

The system of equations is estimated by GMM (Generalized Method of Moments), using \( \gamma_1 \) 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, \( \gamma_1 \) 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 Scckokai 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 \( \alpha^* \), 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
Table 2  GMM estimation of structural equations

| γ   | (A) Lagged Full RBC Users only | (B) Lagged Full RBC Users only | (C) Lagged Full RBC Users only | (D) Lagged Full RBC Users only | (E) Current Full RBC Users only | (F) Current Users only |
|-----|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-----------------------|
| w   | Lagged Full RBC Users only    | Lagged Full RBC Users only    | Lagged Full RBC Users only    | Lagged Full RBC Users only    | Current Full RBC Users only   | Current Users only     |
| Rural comm. with agriculture | Yes | Yes | No | No | Yes | Yes |
| β2  | 1.4930*** (0.4733) | 1.2314*** (0.3769) | 1.4623*** (0.4625) | 1.2013*** (0.3643) | 1.1659*** (0.3061) | 1.4313*** (0.4058) |
| β3  | 2.2434*** (0.4174) | 2.4813*** (0.4724) | 2.1854*** (0.4044) | 2.4100*** (0.4417) | 2.8955*** (0.5129) | 2.6345*** (0.4433) |
| ρ   | 0.6787*** (0.2240) | 0.7084*** (0.2130) | 0.6841*** (0.2256) | 0.7077*** (0.2079) | 0.6406** (0.2760) | 0.5722** (0.2759) |
| α   | 0.6789*** (0.1689) | 0.6781*** (0.1590) | 0.6804*** (0.1684) | 0.6775*** (0.1603) | 0.6798*** (0.1856) | 0.6783*** (0.1966) |
| J test $\chi^2(2)$ | 1.0117 (0.6030) | 1.0639 (0.5875) | 1.0067 (0.6045) | 1.0327 (0.5967) | 0.9871 (0.6104) | 0.8946 (0.6394) |
| p value | 0.6030 | 0.5875 | 0.6045 | 0.5967 | 0.6104 | 0.6394 |
| $R^2$ for x1 | 0.1054 (0.3743) | 0.1083 (0.3565) | 0.1057 (0.3754) | 0.1082 (0.3576) | 0.0957 (0.3587) | 0.0966 (0.3814) |
| Obs. | 90 90 | 90 90 | 90 90 | 90 90 | 96 96 | 96 96 |

Estimation method: nonlinear two-step GMM. Standard errors in parentheses are estimated from a heteroskedasticity-consistent robust variance-covariance matrix. Tax shares $\gamma$ 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 only 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). *, ** and *** respectively denote parameter significance at 10, 5 and 1 % level. Parameter $\alpha$ is estimated in a second stage from GMM estimates, and at the sample mean.

is the case, which implies that parameter $\rho_3$ is not identified because $\alpha^* \approx \alpha^*_2$. Therefore, we consider only the case $\alpha^* = \alpha^*_2$.

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 $\beta_2$, $\beta_3$ and $\rho$ are concerned, but also the average estimate of $\alpha$, around 0.68. All estimates are significantly different from 0 at the 5 % 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%, 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 \( \alpha \) 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 \( \alpha^* \) is evaluated at the sample mean.

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 Widgrén (2004).

In Kauppi and Widgrén (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 \( \gamma \) 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 \( \gamma \) 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:

\[
\begin{align*}
  x_{ijt} &= \beta_0 + \beta_{1j} w_{ijt} + \beta_{2k} w_{ikt} + \beta_{3j} \gamma_{ijt} + \beta_{4j} \gamma_{ikt} + \alpha_{ij} + \varepsilon_{ijt}, \\
  i, k &= 1, 2 \text{ (agriculture, industry)}, \quad j = 1, 2, \ldots, 6; \quad t = 1, 2, \ldots, T,
\end{align*}
\]

where \( x_{ijt} \) is the share of total subsidies received by the user category \( i \) (agriculture, industry) in river basin \( j \) at time \( t \), \( w_{ijt} \) and \( w_{ikt} \) are the proportions of representatives in the River Basin Committee \( j \) for user category \( i \) and \( k \) respectively, and \( \gamma_{ijt} \) is the share of tax payments.
### Table 3  GMM estimation of reduced-form equations

| Dep. variable | Model I | | Model II | | Model III | |
|---------------|---------|---|---------|---|---------|---|
|               | $x_1$  | $x_2$ | $x_1$  | $x_2$ | $x_1$  | $x_2$ |
| 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) |
| $\gamma_1$   | 1.7747** | −1.8911** | 1.2380 | −1.1170 | 1.1170 | (0.7998) | (0.7422) | (1.4106) | (1.0380) |
| $\gamma_2$   | −0.1394*** | 0.9618*** | −0.1165*** | 0.9163*** | −0.1165*** | 0.9163*** |
|              | (0.0413) | (0.0894) | (0.0421) | (0.0946) | (0.0421) | (0.0946) |
| $w_1$         | 1.7603*** | −1.9132** | 0.4144 | −0.1866 | 0.7123 | (0.6023) | (0.7795) | (0.3491) | (0.3579) |
| $w_2$         | 0.3634** | 0.1276 | 0.1843 | 0.0780 | 0.1843 | (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 |
| $\tau$ 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 Instruments for Model I and Model II equations: (1, $\gamma_1$, $\gamma_2$, $w_2$). Instruments for Model III equations: ($\gamma_1$, $w_2$, $\gamma_2$, $w_1$, $w_1 \times \gamma_2$, $\gamma_1 \times \gamma_2$). $\tau$ 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) * , ** and *** respectively denote parameter significance at 10, 5 and 1 % level

to the Water Agency paid by user category $i$. Unobserved heterogeneity specific to river basin $j$ and to the user category is captured by the individual effect $\alpha_{ij}$, and $\varepsilon_{ijt}$ 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 $\alpha_{ij}$ 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 $\gamma$ 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 Widgrén (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 $\gamma_2$ 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 $\gamma_1$ and $\gamma_2$ 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 ($\beta_2$, $\beta_3$ and $\rho$) 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 (2015). 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% level, and that the structural model would be preferred to reduced-form Model III at the 10% 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.

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 (as reflected by a relatively large $w_i$), but also because the probability that a farmer representative is chosen as a proposer ($p_i$) is higher.

### 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.

With the caveats above concerning the necessarily simplifying assumptions underlying our model, 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 user representation in committees, or modify the level of economic instruments such as taxes. The bias towards agriculture in particular (player 1) could obviously be limited if \( w_1 \) is reduced or if \( \gamma_1 \) is increased. Furthermore, if one is ready to accept the simplified representation of bargaining within RBCs proposed with our model, an additional option is to reform voting rules within river basin committees. However, before proposing changes in voting rules for river basin committees, further evidence would be required to supplement our empirical finding that a two-stage representation of the bargaining process is valid. Our bargaining model provides a simplified representation of negotiation over budget in river basin committees, with reasonable performance given data limitations. Although it is certainly not the only relevant representation of bargaining in river basin committees and budget allocations by water agencies, our structural model cannot be rejected when compared with reduced-form models (based on needs view in particular). 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 \( \alpha \) one gets:

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

(23)
Therefore, for maximum on the interval \([0, 1]\), we prove that
\[ V_i' (1) = u''(\gamma_i) \left( 1 - \hat{p}_i - P_i \right) \gamma_i \sum_{j \in \mathcal{N} \setminus \mathcal{S}_i \setminus \{i\}} \gamma_j. \]

Therefore, for \(\gamma_i \geq \gamma_i \) where \(\gamma_i \), satisfies (14).

One can check that: \(V_i' (0) \leq 0 \) if and only if \(\gamma_i \leq \gamma_i \) where \(\gamma_i \) satisfies (14).

Since \(u''(\cdot) < 0 \) it follows from (24) that \(V_i'' (\alpha) \leq 0 \). From (23) it follows that:
\[ V_i' (1) = u''(\gamma_i) \left( 1 - \hat{p}_i - P_i \right) \gamma_i \sum_{j \in \mathcal{N} \setminus \mathcal{S}_i \setminus \{i\}} \gamma_j. \]

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

- for \(\gamma_2 < \frac{\hat{p}_3}{\hat{p}_2} \), function \(V_2 (\alpha) \) is decreasing on the whole interval \([0, 1] \) and therefore \(\alpha_2^* = 0 \);
- for \(\frac{\hat{p}_3}{\hat{p}_2} < \gamma_2 < \frac{\hat{p}_3}{\hat{p}_2} u_2' (0) \), function \(V_2 (\alpha) \) has an inferior maximum \(\alpha_2^* \) on \([0, 1] \) which is defined from the equality \(V_2' (\alpha) = 0 \), that is,
\[ \frac{\hat{p}_3 u_2' (\gamma_2 + \gamma_3)}{\hat{p}_2} = \gamma_3 \]
- for \(\gamma_2 > \frac{\hat{p}_3}{\hat{p}_2} u_2' (\gamma_2 + \gamma_3) \), function \(V_2 (\alpha) \) is decreasing on the whole interval \([0, 1] \) and therefore \(\alpha_2^* = 0 \).

Appendix 2: Derivation of Optimal \(\alpha^*\)

From Proposition 1, the thresholds for group 2 are:
\[
\gamma_2 = \frac{\hat{p}_2 \gamma_3}{\hat{p}_3}, \quad \text{and} \quad \gamma_2 = \frac{\hat{p}_2 u_2' (\gamma_2 + \gamma_3)}{\hat{p}_3 u_2' (0)}. \]

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

- for \(\gamma_2 < \frac{\hat{p}_3}{\hat{p}_2} \), function \(V_2 (\alpha) \) is decreasing on the whole interval \([0, 1] \) and therefore \(\alpha_2^* = 0 \);
- for \(\frac{\hat{p}_3}{\hat{p}_2} < \gamma_2 < \frac{\hat{p}_3}{\hat{p}_2} u_2' (0) \), function \(V_2 (\alpha) \) has an inferior maximum \(\alpha_2^* \) on \([0, 1] \) which is defined from the equality \(V_2' (\alpha) = 0 \), that is,
\[ - \hat{p}_3 u_2' (\gamma_2 + (1 - \alpha) (1 - \gamma_1)) \gamma_3 + \hat{p}_3 u_2' (\alpha \gamma_2) \gamma_2 = 0; \]
- for \(\gamma_2 > \frac{\hat{p}_3}{\hat{p}_2} u_2' (\gamma_2 + \gamma_3) \), 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:

$$\bar{\gamma}_3 = \frac{\hat{p}_3 \gamma_2}{1 - \hat{p}_3}$$ and

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

The behavior of player $3$ can be summarized as:

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

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

$$- \hat{p}_3 u'_3 (\alpha \gamma_3 + (1 - \alpha) (1 - \gamma_1)) \gamma_2 + (1 - \hat{p}_3) u'_3 (\alpha \gamma_3) \gamma_3 = 0; \quad (26)$$

- for $\frac{\gamma_3}{\gamma_2} > \frac{\hat{p}_3}{1 - \hat{p}_3}$, 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 $\frac{\gamma_3}{\gamma_2} > \frac{\hat{p}_3}{\hat{p}_2}$ or player $3$ if the opposite inequality holds.

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