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Negotiation process in water resource management

The standard tools used in water negotiations are intended to favour the mutual comprehension of the stakes by participants and facilitate the construction of more robust agreements in this way. But the organizers of the consultation procedures also need a support to establish the negotiation structure. We illustrate here the utility of a bargaining model to simulate and compare negotiation rules. The applicability of this tool is illustrated by two experimental examples.

Negotiations in water management

The design of public policies in the field of land planning and environmental management has changed in order to favour decentralized and participative approaches based on local consultations and formalization by contracts. Decentralisation allows a better informed decision on the resource characteristics and the participants' preferences and constraints. It introduces more flexibility into the selection of management tools and better adaptation to the local conditions. Theoretically, the principles of subsidiarity and collective action are a guarantee of more autonomous and better coordinated management in which the actors feel involved and responsible throughout their participation in the decision-making and implementation process. Last, looking for a consensus between local actors through dialogue and consultation is supposed to favour the processes of collective learning and mutual information.

It is probably in the field of water management that the legislative progress made to adopt these approaches have been the most significant (Thoyer et al, 2004). Since 1964, through the creation of water agencies, France has built a decentralized, integrated basin-wide water management. The implementation of river contracts since 1981, then the Water Planning and Management Schemes (WPMs) in 1992 have progressively imposed the practice of concerted and contract-based management. This tendency became even more pronounced in 2000 with the European Union water framework directive (WFD) which specifies that the members States will have to "encourage all the parties concerned to participate actively in the implementation of the present directive".

The human and social sciences have explored these new approaches from two points of view:

- The analysis of participatory approaches focuses on the implication of actors and their logic of participation; the process of consensus building through the confrontation and development of preferences; the mediators' role in the dialogue and the resolution of conflicts.
- The operational research works build tools to support and facilitate the negotiation, going from role plays to computer-aided simulations to clarify stakes, reveal the participants' preferences and build multi-criteria decisions.

These works shed limited light on an important matter for the public decision-maker: that of the impact of the negotiation structure on the outcome of the negotiation. Even if the French legislative framework imposes a given representation of the State, regional authorities, and users in the local water commissions (LWC) where the WPMs are debated, many other structuring parameters remain at the initiative of the WPMs coordination group: What rule for collective decision-making? How to structure the steps in negotiation? Must we negotiate on all the dimensions in time only or must we segment the discussions? Must we encourage the formation of sub-groups within the LWC?

Among the research needs in economics, we therefore see the necessity to substitute negotiation building support tools for the classical decision-making support tools. The objective is to offer a simulation tool helping anticipate the impacts of the negotiation configuration on the agreements achieved.

We are going to show a simplified presentation of the model used. Next, we will describe two applications of this model: the first is about negotiation of the management scheme of the Adour river low waters; the second illustrates a negotiation about both the regional planning and management of the Thau lagoon.

A model of multilateral negotiation

In order to model the negotiation process, we make a few simplifying but realistic assumptions:

- The negotiation space must be clearly defined: the stakes to be negotiated are identified and limited (by statutory constraints, for instance). In the

WPMs, it is the diagnosis phase which permits the identification and the consolidation of the variables to negotiate.

- The participants' (or players) preferences in the negotiation can be describedby mathematical functions, called *utility functions* which depend on the value of the negotiated variables. As the model does not require any interpersonal comparison of utilities, , it is possible to build utility functions calibrated on experimental data for some players and on more schematic functions, normalised for others.
- Each player knows the structure of the others' preferences, the negotiation rules and each one's political weight in the negotiation. The local actors have multiple opportunities to exchange and learn how to evaluate their partners' viewpoints and strategies in the consultation.
- If the participants do not agree on a common solution, a third party will take a decision. This decision is often less favourable to the participants than any of the agreements that could have been chosen. This condition guarantees that the players will enter the negotiation process. We often see it in public decisions (for example, the threat of withdrawal of State funds).

The multilateral bargaining model is based on the non-cooperative game theory and allows the simulation of the results of a negotiation between several participants on several simultaneously negotiated variables (Adams et al., 1996). The resolution mechanism is as follows. The negotiation is organized in successive rounds during which each player may make a proposal on all the negotiated variables, with a certain probability (parameter α_i specific to each player i) which reflects its political weight in the negotiation. The other players may either accept this proposal or refuse it and ask to proceed to the following round where the same process is organized. To make a decision, they compare the utility of the proposal made in this round with the utility they could obtain by asking to move to the following round. The negotiation stops when there is a unanimous agreement. In a negotiation structure where the lack of agreement would lead to an unfavourable solution for all, the players adjust their proposals in order to maximise their utility while respecting the others' participation constraints; we can theoretically show that the proposals converge towards a so-called "pareto-optimal" solution: a player's utility cannot be improved without reducing that of another one.

Sharing quotas and water cost in the Adour River

An important question is that of the participants' "bargaining power", that is to say their ability to lead the compromise obtained towards their most-preferred solution. The first intuition is to measure it through their capacity of representation synthesised by parameter α of the model (presence at the negotiation table, status, number of votes). But there are other sources of power, through the game of direct or indirect alliances between players which may introduce non insignificant distortions into the final agreement. For the negotiation manager, it is important to be able to anticipate these negotiation key-elements, even imperfectly.

The simulation model was used to identify and compare the agricultural sector's sources of bargaining power in the negotiation on the implementation of a management scheme of the low waters in the upstream catchment area of the Adour River (South-West France) (Simon et al, 2007). To respond to the increase in conflicts about water use, mainly linked to the increase in irrigation, it was necessary to decide collectively to build new dams and establish new negotiated rules on water distribution and cost sharing.

The basin was schematically subdivided into three sub-basins (upstream, midstream, and downstream) for the exit of which the water development plan established constraints of objective flow to respect. The space of the negotiated variables includes the building of three reservoir-dams able to refill the Adour or its tributaries and therefore partly slackening the flow constraints; the maximum volumes permitted for agriculture in each of the three basins; the sharing between the three sub-basins of the costs linked to the implementation of dams (through differentiated water prices for each of the three sub-basin).

The model schematically integrated seven actors: a "farmer" actor per sub-basin whose utility function was built by aggregation of the profit functions of the sub-basins operators; two "environment" actors defending both the Adour environmental flows and the minimisation of the negative impacts of the dams, the upstream "environment" actor being more sensitive to the second stake than to the first one; The "basin manager" whose objective is to provide users with water while respecting the constraints of hydraulic and budgetary balance; an actor summarizing the interests of the local authorities and domestic users, sensitive to the available volumes for consumption and aquatic environment.

The hydraulic and budgetary constraints were calculated from field data. The three farmer-players' profits were simulated for different quotas and prices values for irrigation water from aggregated mathematical programming models of farms representatives of sub-basins.

The simulated scenarios showed that the farmers of the three basins are both competitors for water sharing and associates in order to obtain a larger global quota. Their interest in cooperation differs according to their location, upstream or downstream from the catchment area and according to the structuring of the negotiation rounds. Figure 1 shows how the farmer representative of the upstream basin may increase its utility by progressively handing over his voting power (measured in this simulation by α_2 which progressively goes from 0.25 to 0) to the midstream basin farmer (whose voting-power goes from 0.25 to 0.5). The latter is able to represent their common interests better faced with the "local authorities" actor.

Other scenarios were simulated and show that the compromise obtained on water sharing between the users and the environment may be radically modified according to the way actors choose to express themselves, individually or through a spokesperson and according to the way the negotiation space is structured.

Inter-communality, regional planning and management of the Thau lagoon

Local authorities participate actively in the consultation processes by coordinating not only their investment and planning projects but also their objectives in terms of environmental quality and regional development. This movement is encouraged by the recent legislative framework: the *Chevènement* law of 1999 launched a process of re-allocation of the municipalities' competencies regarding space development and environmental management towards the Public Corporation of Inter-Communal Cooperation Body (PCICC). The 2006 Law on Water and Aquatic Environments (LWAE) stipulates that the WPMs decisions should be observed by the regional development plans such as the Regional Coherence Schemes (RCS).

But delegating the municipalities' traditional competencies to inter-municipalities may overturn the expression of preferences at the negotiating table: by accepting a greater distance between the electors and their representatives, the stability of the agreements may be weakened. A model close to that presented in the case of the Adour is developed to give the manager the means to assess this risk. It is used to identify the consequences of a policy negotiated at the PCICC scale rather than at the municipality scale. Moreover, it suggests an original and fairly easy method to assess the preferences of the local authorities' inhabitants towards the policy of management of their territory (see frame).

The applicability of the model is illustrated on the Thau basin, a lagoon area South-West of Montpellier. Thau is a shellfish production site and a tourist and sports destination. A remarkable landscape element, it is integrated into a mainly wine-growing catchment area and affected by the fast urban growth of Montpellier and Sète. Thau Lagoon was the subject of several documents on planning and management in order to maintain its water quality, threatened by urban waste, farming nonpoint source pollution and the overflow of visitors. But these collective efforts did not have the expected impact, in particular due to the difficulty of constructing steady collective preferences for the 21 municipalities in the catchment area, the coastal municipalities being resolutely oriented towards tourism and the halieutic vocation of the lagoon, while the rural municipalities are more concerned by the region's wine-growing future. Since 2000, these municipalities have been organized into three PCICC (two conurbation municipalities and one community of municipalities). The elaboration of WPMs started simultaneously with the negotiation of an RCS, with some operations carried out by the same managing structure.

In a simplified way, we may consider that the current negotiation is about the relative importance granted to the four development orientations which have a high potential for impact on lagoon quality:

- favour urban growth (CU)
- favour tourism (CT)
- improve trade and institutional facilities (EQ)
- improve sanitation (AS)

Our simulation tool (Rio and Thoyer, 2008) allows a comparison of the content of the agreements obtained according to the different negotiation scenarios (table 1) and the advantages or drawbacks they engender in municipalities (table 2). Three negotiation structures are compared: a direct negotiation between the 21 municipalities; a direct negotiation between the PCICC, the objective of which is expressed as the average value of the member municipalities' objectives; and a two-round negotiation, a first agreement must be found within each PCICC, these "local" agreements becoming restrictive in the second negotiation organized between PCICC.

The results obtained underline that (i) the negotiation-structuring in PCICC strengthens the priority given to urban growth (0.8 in the case of negotiation between PCICC instead of 0.48 in the case of negotiations between municipalities), in synergy with the reinforcement of curative measures (investments in the modernization of water-treatment plants); (ii) negotiation-structuring in two rounds reinforces the area's tourist orientation. These results are due to the reinforcement of the coastal municipalities' weight in the negotiation through the game of alliances underlying the restructuring in PCICC; (iii) the direct negotiation between PCICC brings a loss in collective utility compared with a negotiation between municipalities or in two rounds. Moreover, losses are unequally distributed between member municipalities (the variance is high), some of whom benefit greatly while others are highly disadvantaged. This may explain the reticence of some of the municipalities or PCICC to go further forward into a grouping rationale.

Conclusion and prospects

The aim of the simulations is not to validate a model by comparing it to reality but rather to enlighten public authorities when they have to start a consultation process. They provide the decision-maker with a simple tool, easily adaptable to a particular situation, in order to make an ex ante assessment of the potential consequences that different organisation forms of negotiation could entail. Even though only some of the dimensions of the real situation are addressed, the results help illustrate how the compromises obtained are distorted according to the discussion-structuring and how the costs and profits of compromises are shared.
In another context, this type of model could also be mobilised as a support tool for negotiations, available for the participants to simulate the consequences of their proposals and communicate about their preferences.

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Figure 1: Utility of the actors when the upstream farmer allocates his political power to the midstream farmer

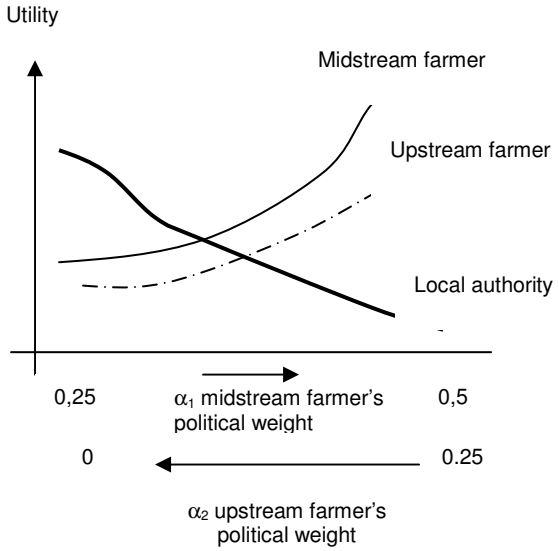

Table 2: Reserved priority according to negotiation configurations

Negotiation configurations	**CU**	**CT**	**EQ**	**AS**
Between municipalities	0.48	0.56	0.47	0.50
Between PCICC	0.80	0.51	0.45	0.56
In two rounds	0.51	0.60	0.44	0.54

Note: a value close to 1 indicates that the agreement obtained favours the corresponding policy, 0 expresses a rejection of the policy.

Table 2: Relative disutility of the municipalities in the various negotiation configurations

Negotiation configurations	related to a decentralised policy	
	Average	**Variance**
Between municipalities	1.0000	0.0000
Between PCICC	1.1450	0.1626
In two rounds	0.9973	0.0062

Frame

The utilization of the model requires translation of various participants' preferences on the negotiated variables into a continuous mathematical function. In the case of Thau, we favoured a simplified approach using only the INSEE (French Institute of Statistics) statistical data. Each municipality i is characterized by a function of disutility DU_i which is analysed as the aggregated utility loss of the electors of that district resulting from acceptance of a compromise (represented by the values X_1, X_2, X_3 et X_4 for the 4 negotiated policies, respectively CU, CT, EQ end AS) with the electors' objectives from the other districts. We assume that the municipality has an ideal value for the 4 policies (A_1, A_2, A_3 et A_4) which would be the one it would implement if it took the decision alone. Any deviation from this ideal point lowers its utility according to the intensity of its preference for this policy γ_l^i. The function of disutility Du_i described above translates these assumptions.

$$DU_i = \sqrt{\sum_{l=1}^{4} \gamma_l^i (A_l^i - X_l)^2}$$

Therefore, the stake is to assess parameters γ_l^i and $A^i{}_l$ for each of the municipalities. We make the elector-politician models from the theory of public choices which assumes that the representatives implement the policies which maximize the weighted sum (by their numerical weight) of the satisfaction of the various socio-economic components of their electorate. The French Statistic Institute's data give us the necessary information on the policies implemented by the municipality in the past and on its demography. Econometrical estimations linking both types of variables allow us to deduct the ideal points and the intensity of the municipality's preferences from estimated parameters.

For further information

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