INFLUENCE OF DISCOUNT RATES AND CATCH LEVELS ON THE NEGOTIATION OF FISHING RIGHTS

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ABSTRACT

When dealing with time, a fishery manager faces a major difficulty. On an N-period time horizon, should he follow several short-run objectives for every n sub-period, or should he consider only the long-run objective? If a European manager trying to implement a stock recovery plan prefers to achieve the long-run objective as rapidly as possible, will the member-state governments follow the same guideline with their own goals? They may prefer a shorter horizon matching their own political cycle. Suppose the European Commissioner wants to reduce the fishing capacity within five years along a monotonic decommissioning scheme, one of the member-states might keep on fishing with the same level of effort for one or two years before reducing its fishing fleet.

On the basis of a non-cooperative game, this communication looks at the role of a mediator (say the European Commissioner in charge of negotiating the sharing of fish quotas between the member states) whose goal is twofold: the recovery of fish stocks and the search for optimal solutions between member-states having different discount rates and different catch levels. This optimal solution is obtained through a jointly-improving process. Both level of catches (size of the country) and time preferences (discount rates) are supposed to affect the result of the negotiation, as well as the negotiating procedure itself (several bargaining methods are compared). The introduction of a new country in the process (e.g. a new member state), by creating opportunities of coalition, is also likely to affect the role of the mediator.

Keywords: negotiation process, fishing rights, time preferences, stock recovery

INTRODUCTION

The dramatic level of a few European fish stocks for the last decade pushed the European Commission to implement in February 2002 some severe recovery schemes to restore rapidly the fisheries. Time plays a crucial role if uncertainty surrounding the estimation of stock levels and the long-run effects of a high fishing mortality rate are to be taken into consideration, both resulting in the depletion of natural resources. To be successful, the recovery plans require the unconditional compliance of all fishing countries to the same goal of rebuilding the fishery. Nonetheless, the negotiation of TACs, quotas and fishing effort levels includes political aspects that sometimes do not fit with this goal. In economic terms, one must admit that the social discount rate is far from being known and that every member state has a different motivation to comply with the objectives of the Common Fisheries Policy.

Such a situation offers an interesting analytical perspective for game theory, the latter being used for a long time by those economist working on the negotiation process of fishing rights [1,2,3]. This theoretical framework sets up the conditions under which negotiation can be successful and the welfare consequences for all participants. Some authors have used a pareto-improving procedure from a simple model called the “fishwar game model” in order to represent the dilemma of common-pool renewable resources [4]. However the authors forgot to consider how sensitive the results were to the original conditions of the negotiation for each player, in particular the respective distribution of fishing rights and discount rates at the beginning of the process.

The present communication analyses the influence that such conditions may have on the negotiation outcome. Several settings are scrutinised, along with various negotiation procedures, according to the priority of the policy manager aiming at rebuilding the fishery as soon as possible. The introduction of a third (and more) player(s) is likely to affect the negotiation dynamics between the member states and the manager through the coalitions borne in the middle of the process.

THE PROBLEM OF TIME LIMIT FOR THE MANAGER

Time plays a key role in fisheries management. Economic theory offers two basic approaches to deal with it: using time as a constraint to determine the period (time quantity) within which economic action may achieve a fixed objective for every sub-period and for the whole period; using time through a discount rate to estimate the present value of costs and benefits within a fishery (time quality).

Economic dynamics and social discount rate

Basically the first approach deals with dynamics issues through optimal control models (maximising the fishery surplus under the constraint of a steady state variable like the growth of natural stock). The fishery manager sets an objective for every sub-period throughout a planning horizon. Here comes the problem of choice regarding the kind of control/action that should be taken: should it be a series of pre-defined actions, a series of actions changing with the path dependency, a series of actions defined on a fixed sub-period and re-negotiated at the end of it?

The second approach refers to classical economic calculus: cost-benefit analysis, assessment of the net present value. It shows how impatient the decision-maker can be. The social welfare decreases when resource allocation is based on a discount rate being different from the social discount rate (SDR) [5]. The dynamic equilibrium of the fishery is obtained when the rate of return issued by the stock growth rate equals to the SDR. The problem is that economists do not agree upon which value of SDR should be used. Rowse [5] shows nonetheless that the social loss remains very low whatever the value of SDR because the effects on the consumer surplus are offset by the effects on the producer surplus (Rowse had demonstrated the same kind of result for exhaustible resources in a previous article of 1990). However the impact on stock levels and the path of optimal catches is far from being negligible. Moreover the depressive effect on social surplus will be all the more important as stocks grow at a low rate. Many other articles emphasise the role of the “right” SDR [6,7,8,9,10].

Obviously, these two approaches are connected: the national fishery manager in a EU member state who tries to stop overfishing within a 5-year period is therefore indifferent to what may happen in ten or twenty years time. Nevertheless, should he decide urgently to adopt severe measures to reduce rapidly the fishing capacity or should he prefer to follow a smoother transition path to reach the same goal?

The recovery plans in the Common Fishery Policy reform of 2002

A conflict between the short and the long run may occur for the manager. Suppose that the European Commissioner chooses the most rapid way to achieve the recovery of stocks. How could he be sure that other decision makers (member state managers under the pressure of their domestic industry) will choose the same time horizon? “A management policy becomes effective with choices, priorities, and compliance with the negotiated arrangement. The international level makes it even more difficult because the different partners involved in the fishery follow different objectives: one wants to save the jobs at sea, another one would rather supply its processing industry, the third one prefers to reduce the ecological impact on the fishery” ([11], p. 4). This key actor of the Common Fishery Policy for the last decade adds: “the true division relates more to time scaling. To deal with the issue of ‘which sustainability for which stake-holder’, one should first analyse the time scales of the different partners” ([11], p. 18).

The issue becomes even more significant in the case of the negotiation process of fishing rights. The national quotas have been implemented for more than two decades as negotiated shares of the Total Allowable Catch (TAC) for a particular species in a particular fishing zone. They are often called ‘bio-political’ to outline the harsh negotiation process between EU member states that rules the allocation of quotas sometimes far away from the scientific advice. Their relative failure to stop the collapse of major fish stocks led the European Commission to implement recovery plans for species like cod (two regulations were adopted : R254/2002 of 12 February 2002 for cod in the Irish sea, ICES zone VII ; R423/2004 of 26 February 2004 which extends the regulation to West Scotland, Kattegat, Skagerrak and the English Channel; other recovery plans were proposed for sole, hake and nephrops).

The multiannual recovery plan has an horizon of 5 to 10 years. The overall objective will be achieved if the spawning stock of cod is above the biological safety level. The fishing mortality rates are controlled through annual TACs and levels of fishing effort in terms of fishing days in order to comply with these TACs. The TAC is set up at a level allowing a 30% growth of the spawning stock at the end of the year. The TAC is also constrained by a maximum fishing mortality rate and a proportional adjustment of the fishing days (R423/2004).

As long as the targeted level of stocks has not been achieved and sustained as this level for two successive years, the recovery plan remains entirely in force. As soon as it is achieved and that the rebuilding is considered to be effective, the multiannual management plan (R2371/2002, chapter 6), more flexible for the fishermen, comes into force.

Some EU countries, whose discount rate is high, may not comply rapidly with the objective whereas others can find an interest to achieve the recovery of the stock as soon as possible. “The country who faces lower production costs and/or cheaper access to high-value markets, is likely to stand more easily a low level of stocks than others (…). This country is perhaps less willing to accept severe emergency management measures. The consensus for such measures will be more difficult to achieve because the benefits and losses are too unevenly shared among the countries” ([11],

p. 4). On the other hand, although negotiated, the national self-limitation of catches and effort can go beyond the limits imposed by the European Commission for some other countries so as to accelerate the recovery process.

A simple fish war model is introduced in the following section to analyse the consequences of the original settings (discount rate, catch levels) of the countries involved in the negotiation process of fishing rights on their compliance with the common endeavour of stock recovery. One of the issues concerns the role of the mediator: can he influence the convergence of decision-makers towards the objective of stock recovery with regard to the selected negotiation procedure?

PARETO OPTIMAL SOLUTION IN A FISH WAR GAME

The Model

The "Fish war game" [2] has been used for the demonstration. This game model considers two countries involved in a common-pool fishery. Their utility functions are respectively:

$$U_1 = \log x_1 + \beta_1 \log(Q - x_1 - x_2)^\tau \quad \text{(Eq. 1)}$$

$$U_2 = \log x_2 + \beta_2 \log(Q - x_1 - u_2)^\tau \quad \text{(Eq. 2)}$$

With $0 < \beta_1, \beta_2 \geq 1, 0 < \tau < 1, 0 < Q < \infty$, and

$$(x_1, x_2) \in D = \{(x_1, x_2) : x_1 \geq 0, x_2 \geq 0, \\ x_1 + x_2 \leq Q\}. \quad \text{(Eq. 3)}$$

Each country tries to maximise its utility relying partly on the other country's decision. x_1 and x_2 are the catch levels (or the original fishing national quotas based on track records) of countries 1 and 2 respectively, τ is the instantaneous growth rate of the fish stock, and β_1, β_2 represent the preferences for the future. The higher the value of the latter and the more the country is willing to sustain a high level of fish stocks. Indeed these preferences valuate the willingness of country i to reduce structurally its harvesting level. The Q variable represents the total allowable catch of the species in the fishing zone.

It is quite clear from the utility functions that one country is more likely to reduce its effort if its own rate of preference for the future is high and that the other country follows the same strategy. As reported below, the strategies of the two countries can nonetheless be opposite.

Nash Equilibrium of the game

Given Q, the reaction functions are obtained from:

$$x_1^* = T_1(x_2) \Leftrightarrow \frac{\delta U_1}{\delta x_1} = 0 \quad \text{(Eq. 4)}$$

$$x_2^* = T_2(x_1) \Leftrightarrow \frac{\delta U_2}{\delta x_2} = 0 \quad \text{(Eq. 5)}$$

with $T^i : R \to R$, the reaction functions of player i, $i = 1, 2$ are :

$$x_1 = \frac{Q - x_2}{1 + \beta_1 \tau} \quad \text{(Eq. 6)}$$

$$x_2 = \frac{Q - x_1}{1 + \beta_2 \tau} \quad \text{(Eq. 7)}$$

The Nash equilibrium is given by the couple $(x_1^N, x_2^N) \in T_1 \cap T_2$:

$$x_1^N = \frac{\beta_2 Q}{\beta_1 + \beta_2 + \beta_1\beta_2\tau} \quad \text{(Eq. 8)}$$

$$x_2^N = \frac{\beta_1 Q}{\beta_1 + \beta_2 + \beta_1\beta_2\tau} \quad \text{(Eq. 9)}$$

Numerical application with $Q = 1.259$, $\tau = 0.2852$, $\beta_1 = 0.9$ and $\beta_2 = 0.4$. We obtain $x_1^N = 0.359$, $x_2^N = 0.807$, $U_1^N = -1.636$, $U_2^N = -0.485$. The harvested quantity is 1.166.

Co-operative equilibrium

Suppose now that the two countries co-operate, then the maximising problem becomes:

$$\underset{x_1,x_2}{Max}(U_1 + U_2) \Rightarrow \begin{cases} \dfrac{\delta(U_1+U_2)}{\delta x_1} = 0 \\ \dfrac{\delta(U_1+U_2)}{\delta x_2} = 0 \end{cases}$$

The so-called co-operative solution is:

$$x_1^c = \frac{Q}{2 + \beta_1\tau + \beta_2\tau} = x_2^c \quad \text{(Eq. 10)}$$

With previous values, we obtain $x_1^c = 0.531 = x_2^N$, $U_1^c = -1.052$ and $U_2^c = -0.818$, hence a catch quantity of 1.062. Let's note that if the sum of welfares is greater than the one obtained with the Nash equilibrium, it would result in an unequal sharing which would be detrimental for country 2. The latter is then unlikely to accept such a re-allocation of catches.

Suppose now that the two countries try to negotiate an outcome different from the Nash equilibrium. The previous statement leads to:

- either a (monetary or other) transfer from country 1 to country 2 [1]
- or another solution brought up by the negotiation process

In the latter case, the mediator/manager now plays an important role. Could this mediator intervene in the negotiation process to drive it towards a solution which would still be, although different from the co-operative one, a pareto-improving solution for both countries?

The Pareto optimal solution

Let the Nash solution couple be $x^N = (x_1^N, x_2^N)$. Suppose that the mediator begins the negotiation process with this couple. He will then propose another solution couple $\overline{x} = (\overline{x}_1, \overline{x}_2)$. Each country i will prefer this new couple if $U_i(\overline{x}) > U_i(x^N)$, will be indifferent if $U_i(\overline{x}) = U_i(x^N)$, and will not accept this new couple if $U_i(\overline{x}) < U_i(x^N)$.

<u>Definition 1 :</u> A couple of catches $\overline{x} = (\overline{x}_1, \overline{x}_2)$ dominates a couple $x = (x_1, x_2)$ if and only if: $U_i(\overline{x}) \geq U_i(x)$ and $U_j(\overline{x}) > U_j(x)$, $\forall j \neq i$. This couple will be declared as Pareto optimal.

Ehtamo *et al.* [4,12] have provided an iterative approach allowing the mediator to propose couple solutions. This approach is based on three steps:

- <u>Step 1 : Improving direction</u>: stemming from an initial position, $x = (x_1, x_2)$, the mediator determines the preferred directions of each country (i.e. towards more or less harvest);
- <u>Step 2 : Compromise direction</u>: the mediator calculates the jointly-improving direction;
- <u>Step 3 : Proposition</u>: the mediator determines the new solution couples and chooses among them one couple to propose it to the two countries; the latter will accept it only if their utility increases.

According to [4], the mediator must adopt a « small-step » procedure, i.e. if two solution couples emerge at stage 3, the mediator must propose the nearest couple of the starting point. The three stages are presented below in the case where the mediator knows the utility function of each player. If this is not the case, some procedures revealing the preferences should be first implemented by the mediator.

Although the article of Ehtamo *et al.* ([12], p.60) demonstrates that this iterative approach converges, if the propositions are acceptable, towards a Pareto optimal equilibrium –at least weakly-, some problems are still unclear in the fish war game model:

- How do the β_i rates influence the result ? Same question for the initial fishing rights.
- Why only this « small step » process should be used?
- If the number of countries is greater than two, what will be the answers to the previous questions? What could be the influence of a coalition between two (or more) of the three (or more) countries on the negotiation process?

THE NEGOTIATION WITH TWO COUNTRIES

If the process described above guarantees a convergence towards a Pareto-optimal equilibrium in a two-country framework, the final solution as well as the expected outcome depend however to a great extent on two features of the model: the respective catch levels at the inception of the negotiation process (or the fishing quotas x_i) on one hand, and the time preferences of the two countries (β_i) on the other. Presumably, the specification of the model (functional form) also plays an important role, but this will not be further discussed within the article. The sensitiveness of the results to the parameters of each country will be first analysed before examining the impact on the fish stock and the respective contributions of each partner to its recovery. The effectiveness of the negotiation process will be simply analysed in terms of stock levels on the basis of the harvesting rate (Σx_i / Q), and not in terms of expected utility gains, this latter criterion being implicit to the Pareto-improving solution and finally correlated to the stock levels.

Sensitiveness analysis

Like the structure of the game presented in [4], an opening negotiation towards a catch increase is foreseeable, although this negotiation margin remains narrow (Σx_i =1.2 and Q=1.259 at the beginning, under the constraint $\Sigma x_i \leq$ Q).

Impact of time preferences

Due to the form of the utility function, it is quite clear that a country which would first accept to reduce its own harvest (hence a decrease of its separated short-run welfare) should countervail this loss in the long run by a welfare gain issued from its responsible behaviour with respect to the future level of stocks. We observe that this benefit depends on the β_i values, kind of inverse discount rates where a high value corresponds to a strong involvement of the country in the stock recovery process which benefits to all countries.

Because of the model structure, the expected welfare gains (gap between final and initial utility) will be greater as the sum of β_i is higher and that both countries have a sustainable fishing behaviour. Total harvest will be at the lowest if preferences for the future are strong. The relationship between welfare gains, key index of pareto-optimality, and the overall reduction of the fishing effort is therefore directly deduced from the game framework. Admitting that the mediator's main goal is to maintain the fishing mortality rate at its lowest possible level, the aims of the two member states and the regulator should match in the long run. Traditionally for the tragedy of the commons, it is not so and the dynamics of negotiation may significantly diverge from this target despite its common rationale for all players.

Looking for a relationship between the difference of time preferences between the two countries and the global catch level is not so successful. It simply highlights unstable results when the difference is small against a higher pressure on stocks when the difference is big. Such a variability may be due to the initial endowments of fishing quotas.

Impact of the initial distribution of catches

It is difficult to isolate the country size effect (in terms of harvested quantity) in the negotiation process because of the prevailing impact of time preferences. Although marginal, the initial allocation of fishing rights should not be neglected, as shown in the following point. The original relative size of the countries (x_i dep) does not matter as much as the future value of catches (β_i), as shown in the following regression tree:

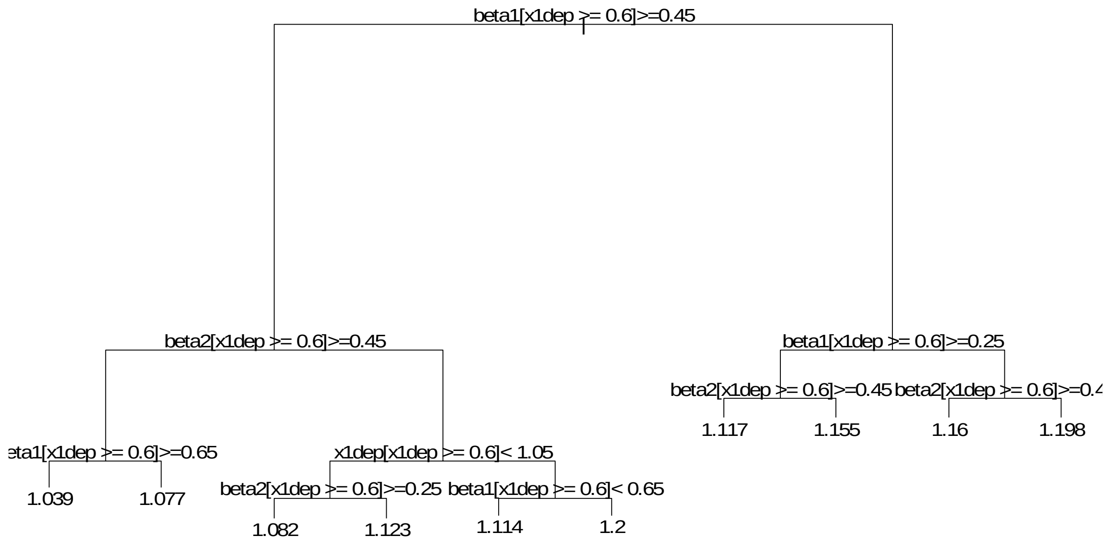

Figure 1: Harvest level with regard to the original endowment of the countries

The condition reported on each node of the graph holds for the left-hand side branch of the tree. The total harvest level is displayed at every end of the branches. The total catches show the significant impact of time preferences: the respective values of β_i almost fully determine the pay-off of the game, whatever the initial quota endowment. The following table compares final catches for different values of β_i and X_i:

Table 1: Total catches achieved with different values of β_i and X_i

Total catches (variation of catches for country 1 and country 2)	X_1 dep =0.1	X_1 dep =0.6	X_1dep =1.1
β_1=0.1 β_2=0.1	**1.2237** (+0.006, +0.018)	**1.2241** (+0.012; +0.012)	**1.2237** (+0.018;+0.006)
β_1=0.1 β_2=0.9	**1.2** (0;0)	**1.112** (+0.004;-0.093)	**1.2017** (+0.001;+0.001)
β_1=0.3 β_2=0.7	**1.2** (0;0)	**1.1036** (-0.032;-0.064)	**1.1499** (-0.046; -0.004)
β_1=0.6 β_2=0.6	**1.0756** (+0.009;-0.134)	**1.075** (-0.062;-0.062)	**1.0756** (-0.134;+0.009)
β_1=0.9 β_2=0.9	**1.0022** (0;-0.197)	**1.0018** (-0.099;-0.099)	**1.0022** (-0.197;0)

Several comments can be made:

(i) If β_i are equal, the initial sharing of fishing rights has no influence on catches

(ii) The higher the β_i, the lower the final catches

(iii) If one of the countries enjoys a high level of initial rights, its individual contribution to the reduction of catches increases with the value of its β_i ; if a country is poorly endowed initially, the same results happens, although $\beta_{j\neq i}$ make the negotiation successful or not. The negotiation is more likely to be successful if the other country's preference for the future is high and that the β gap is small. Interestingly, such a condition is not necessary if the negotiation procedure is different from the "small step" one.

Maximum rebuilding of the stock

Total catches will be lower and stock recovery faster if the two countries have a high value of β. However let's distinguish between the cases where the b-values are identical from the other situations.

- If $\beta_1 = \beta_2$, the closer the countries in terms of initial fish rights and the better the impact on catch decrease, the contributions being shared between the countries.
- If $\beta_1 > \beta_2$, the final catch levels will be lower if country 1 has a much bigger initial fish right than country 2. Country 1 can give up a bigger share of its catches, being the only country paying attention to the future level of the stock.
- If $\beta_1 > \beta_2$ and that the difference is large, a too big endowment of country 1 may disrupt the

negotiation and make it fail. A threshold effect appears to isolate country 1 in its contribution to the stock rebuilding. The lack of co-operation from country 2 has a negative impact on a win-win strategy, despite the low weight of country 2 (once again, β–values prevail on X_{dep}).

On the basis of previous results, the final catch level is very sensitive to β_i but in no way to X_i dep when the β_i are identical. The joint sensitiveness of both variables changes the relationship between total catches and initial quotas: sometimes decreasing with X_1 dep when β_1 increases and β_2 keeps a constant and low value, sometimes increasing when β_1 diminishes and β_2 increases.

Maximum individual contributions

The most influential variable regarding individual incentive to rebuild the stocks remains the preference for the future. Given β_1, the size of country 1 represents the second determining variable. Finally, the difference between the two β values explains the involvement of country 1. This involvement will be greater in the stock recovery if country 2 has a small fish quota at the beginning of the game and does not pay much attention to the future stock levels. In such a situation, country 2 (small country with a weak preference for the future) will even demand from the big country having a strong preference for the future a contribution that allows the former to increase its own quota ($\Delta x_1 < 0,\ \Delta x_2 > 0$).

Opposite contributions to stock recovery

The previous statement holds imperfectly when looking at settings resulting in opposite individual contributions to stock recovery (one of the countries increases its harvest level while the other decreases it). Indeed the ranking of conditions is just upside down: the two contributions to the stock rebuilding plan will be opposite if:

1°) one of the countries enjoys a high quota level at the beginning of the game

2°) its preference for the future is important

The following figure shows that the slope of the curve between the size of the country and the gap of contributions to stock recovery remains the same; its co-ordinate shifts in proportion as the preference for the future of this country increases.

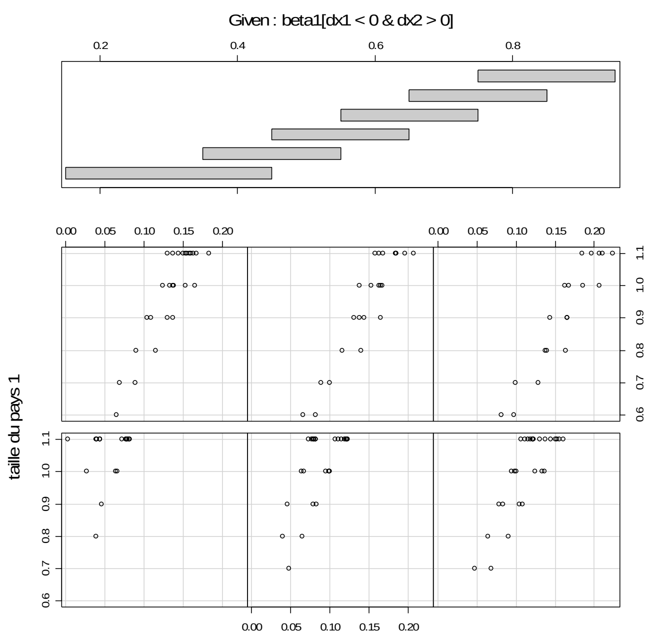

Figure 2: Gap of individual contributions to stock recovery

Among the settings where contributions are opposite and the negotiation goes through, none has resulted in overfishing (i.e. Σxi > 1.2). The country paying greater attention to the future of natural resources would rather leave the negotiation if its involvement was to be countervailed by the partner.

Depletion of the stock

The negotiation can also lead to overfish the quota. The hierarchy of variables influencing the total catch increase is the following one:

- If β-values are identical and equal to 0.1, then a symmetry in terms of initial fish quotas increases the probability of overfishing

- If $\beta_1 > 0.1$, then overfishing only occurs if $\beta_2 = 0.1$. In such a situation, overfishing is rather enhanced by an asymmetry of the two countries where the leader has a $\beta = 0.1$

The size and β of country 1 have a negative joint effect on the fish stock: the bigger the country the lower its preference for the future must be to deplete the stock with country 2. When β_2 is different from 0.1, the size of country 1 poorly matters as long as its preference for the future is weak (=0.1).

To summarise, various settings were analysed to show the influence of the parameters on the likelihood to rebuild the fish stock. Undoubtedly, the structural influence of discount rate is stronger that the initial distribution of catch levels (or fish quotas). The latter's impact is almost neutral when the preferences for the future are identical, revealing the existence of the social discount rate. On the other hand, the role of the discount rate may disappear behind the original endowment of fish quotas to explain why the two countries operate in opposite ways in the stock recovery process. An equal distribution may even strengthen the harmful impact that weak preferences for the future may have on fish stocks.

INFLUENCE OF THE MEDIATOR

The iterative methodology of Ethamo *et al.* [4,12] gives two potential solution couples x' and x'' at every round of the negotiation process. The mediator chooses the option which is the nearest of the starting point. This approach has been called the « small-step procedure ». Such a careful approach is adopted because a too big step is likely to mismatch the pareto-optimal solution. Nevertheless, there are situations where only « big steps » can unlock the negotiation. In particular, negotiation fails with the « small step » approach when one of the countries dominates largely the partner.

Let's compare the « small step » approach (procedure 1) with two other procedures :

- Procedure 2 : Smooth harvest limitation procedure
- Procedure 3 : Conservation policy (minimum catches at each round of the negotiation process without any permitted increase of catches and reverse possibility)

In procedure 2 the mediator will select the solution couple that provides with the highest total harvest limitation, whatever the evolution of catches (upwards or downwards). When the negotiation process results in solutions that temporarily increase the total level of catches, these solutions will be accepted. With procedure 3, the mediator will only propose intermediate solutions that reduce the fishing effort, no increase being accepted during the negotiation process.

If the countries have similar time preferences and fish quotas, procedures 1 and 2 converge. In such a case, the two solution couples x' and x'' will always be identical. The outcome of procedure 3 will be therefore always different from the two others.

Negotiation failures

Table 2 shows the total number of negotiation failures regarding the type of achievement (no move or catch increase). A negotiation will be considered as a failure if the final level of catches equals to the starting point ($\Sigma x_i = 1.2$) or even overshoots it. In both cases, the failure status is abusively reported because the two players have achieved a weak Pareto optimum with respect to the negotiation procedure previously defined. However the statement of the mediator prevails in the respect of the stock recovery process.

Table 2: Number of failures according to the negotiation procedure*

Number (%)	Procedure 1	Procedure 2	Procedure 3
Negotiation sticking to the starting level 1.2	44 (4.9 %)	72 (8.1 %)	123 (13.1%)
Negotiation resulting in catch increase	51 (5.7 %)	51 (5.7 %)	0 (0%)
Total number of failures	95 (10.6 %)	123 (13.1%)	123 (13.1%)

* 891 different negotiations were analysed.

The results are found logically. The "small step" procedure enhances the likelihood of success for the negotiation. If procedures 2 and 3 lead to the same rate of failure, procedure 3 will never allow the overfishing of initial quotas.

The 72 failure cases of procedure 2 do not overlap with the 44 cases of procedure 1 (Table 3). With country 1 paying little attention to the future of resources (β_1=0.1) and country 2 taking great care of them (β_2=0.9), the smaller the original fish quota of country 1 the more country 2 (« the big country ») must participate alone to the stock recovery process, reducing its own fishing effort. Remember that the « small step » approach does not allow such a big shift to achieve a successful negotiation. Procedure 2 allows for a more radical negotiation, hence the success in case of asymmetry of the two countries.

Table 3: Comparison of procedures 1 and 2 for asymmetrical countries

β_1	β_2	X_1 dep	X_2 dep	Δx_1 (M1)	Δx_2 (M1)	Δx_1 (M2)	Δx_2 (M2)
0.1	0.9	0.1	1.1	0	0	+0.057	-0.219
0.1	0.9	0.2	1	0	0	+0.044	-0.192
0.1	0.9	0.3	0.9	0	0	+0.032	-0.165
0.1	0.9	0.4	0.8	+0.021	-0.142	+0.021	-0.142
0.1	0.9	0.5	0.7	+0.012	-0.117	+0.012	-0.117
0.1	0.9	0.6	0.6	+0.005	-0.093	+0.005	-0.093

In all the settings, procedure 2 is successful when procedure 1 fails. This will only be true for procedure 3 if the outcome of the negotiation is compatible with a reduction of catches (fig. 3). The failure conditions of procedures 2 and 3 can hardly be specified. Apparently they lie in situations where the effort demanded by the mediator is too important for the two countries (fig. 4).

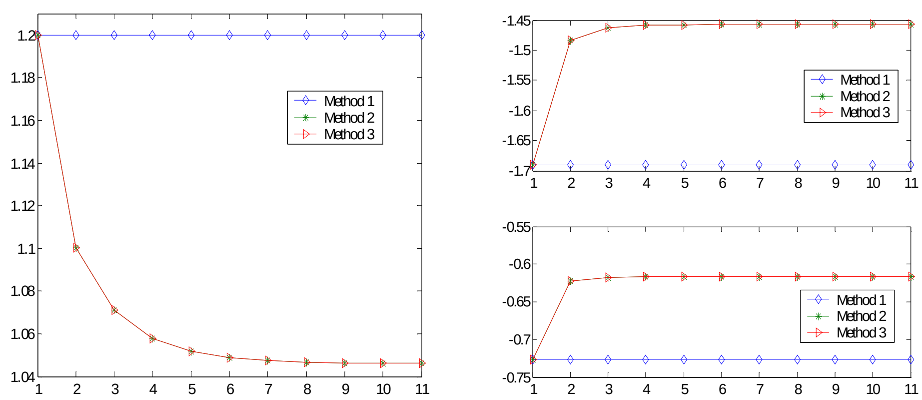

Figure 3: Evolution of total catches and welfare with respect to the procedure (β_1=0.1, β_2=0.9, x_1=0.2 and x_2=1.0)

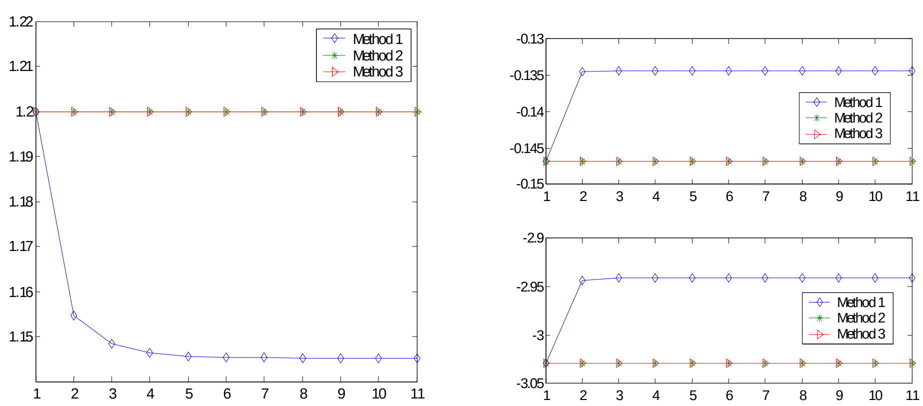

Figure 4: Evolution of total catches and welfare with respect to the procedure (β_1=0.3, β_2=0.9, x_1=1.1 and x_2=0.1)

Specification of the negotiation dynamics

If the three procedures may result in different achievements, procedures 1 and 2 converge in most cases when they do not fail. Comparing procedures 1 and 3, the issue of individual contributions to the stock recovery scheme becomes interesting. The reduction of catches obtained with procedure 3 requires the increasing participation of at least one country. Such an endeavour cannot be demanded to the country whose preference for the future is greater because it has already lowered substantially its claim on resources, but rather from the other country less willing to rebuild the stock. This would explain why the latter loses so much of its welfare as compared to that achieved with procedure 1, and symmetrically for the former country. The number of failures for procedures 2 and 3 can also be better understood: the additional sacrifice is often not accepted by country 2.

THE NEGOTIATION WITH N PARTNERS

In the case of two countries, it has been demonstrated that their own characteristics (original quota, preference for the future) as well as the selected procedure do affect the negotiation process. Nevertheless, a game with only two countries is not realistic. What would be the impact of additional players on previous results? As soon as the number of players reaches 3 or more, a coalition of interests between several countries has to be taken into consideration.

Impact of the third country

The consistency of previous results is an important issue when including a third or even more players. As shown by table 4, the major impact is the increasing number of negotiation failures. It becomes more difficult for the mediator, even with the « small step » approach, to achieve a Pareto optimal solution, the rate of failure reaching more than 60% with four countries.

Table 4: Failure rates with the number of countries involved in the negotiation process

Number* **(%)**	2 countries	3 countries** (β_2=β_3)	3 countries	4 countries
Negotiations sticking to the starting level of 1.2	44 (4.9%)	1036 (23.3%)	10170 (25.4%)	255774 (61.9%)
Negotiation resulting in catch increase	51 (5.7%)	109 (2.4%)	247 (0.6%)	13 (0.0%)
Total number of failures	95 (10.7%)	1145 (25.7%)	10417 (26.0%)	255787 (61.9%)

* The number of cases were respectively 891, 4455, 40096 and 413344.

** A restriction of symmetry was imposed to the time preferences of countries 2 and 3 in order to avoid a large number of possible interpretations.

The positive relationship between preferences for the future and total catches holds with N countries (fig. 5). Nevertheless, the original distribution of fish quotas plays a bigger role in the case of a 3-player negotiation as compared to a bilateral negotiation.

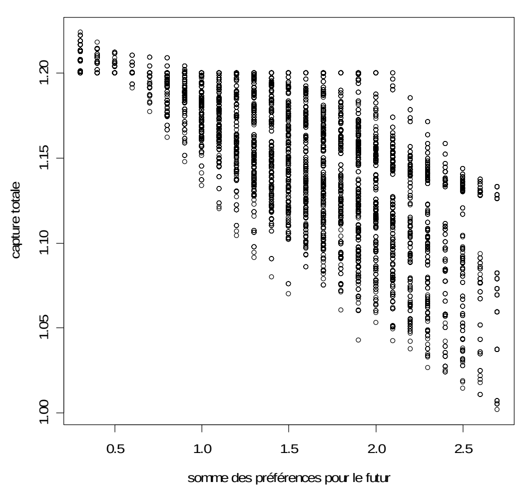

Figure 5 : Impact of the sum of time preferences on the final level of catches

Impact of a coalition

By including a third country in the negotiation process, a coalition between two of the countries against the other is now possible, either at the inception of the procedure or later on in the process. A condition of identical time preferences was adopted in order to match the actual settings and to avoid the problem of which common discount rate should be kept. The results were as follows:

- When the coalition mitigates the original imbalance of bargaining power based on the difference between quotas and between discount rates, it reduces the risk of failure (fig. 6);
- Conversely if the coalition enhances the imbalance, the risk of failure increases;
- The expected benefits of a coalition are greater if the countries co-operate rapidly by decreasing their

fishing effort;

- The rate of failure for the first round of the negotiation with 3 countries is similar to that with 2 countries (4,9%).

Finally, unless the three countries have exactly the same preferences for the future –hence no benefit can be expected from the coalition because the game becomes co-operative-, coalitions between two of the countries having the same discount rate will always benefit to all the countries, whatever the round of the coalition.

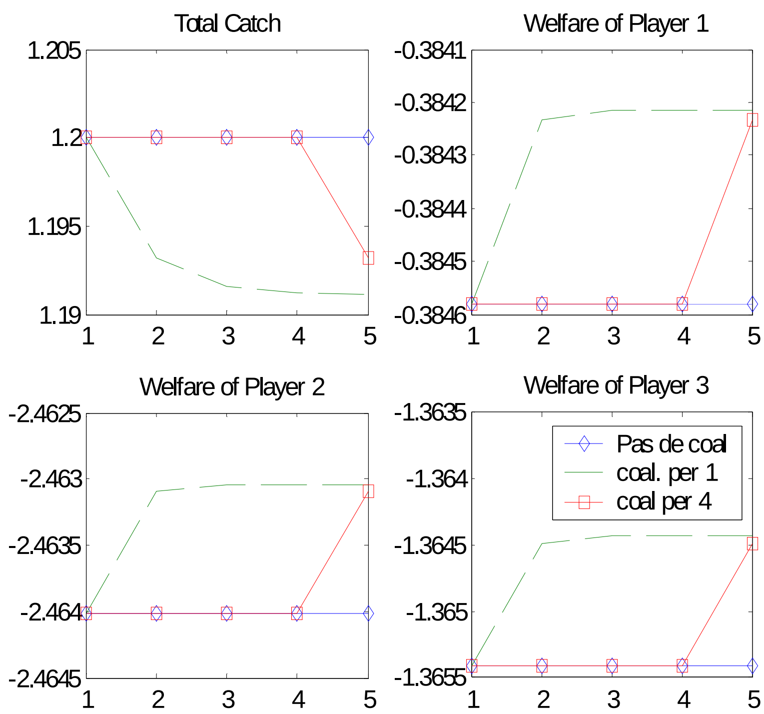

Figure 6 : Case in which coalition unlocks the negotiation (β_1=0.2, β_2=0.2, β_3=0.2, x1=0.8, x2=0.1; x3=0.3)

CONCLUSION

Theoretically, the original distribution of fish quotas and time preferences play a key role within a negotiation whose aim is to rebuild rapidly a depleting stock. The concern of the partners about the future level of the stock dominates any other type of consideration, this result being reasonably expected by any fisheries economist.

Nevertheless, the role of the mediator is not neutral regarding the incentives or constraints that he may put into the negotiation process to achieve a substantial limitation of fish catches. He can demand from the less virtuous country to increase its contribution to the recovery process. If the so-called "small-step" approach is interesting because of the low rate of negotiation failure, it is likely to postpone the effective rebuilding of fish stocks, in particular if the hysteresis of depletion is high for the spawning stock. The long run impact would threaten the future of the stock itself. A possible extension of this research would be to check the consistency of the results in a dynamic framework, using a classical bioeconomic surplus model [1,3].

Another way lies an in-depth analysis of coalitions and their consequences on a co-operative goal. First of all, several issues have not been tackled in the present analysis: what would be the impact of a coalition between countries having different discount rates? In connection with other works [13, 14], more attention should be paid to the stability of coalitions. This author has found unstable coalitions if the countries are symmetrical:: «*We show that with symmetric agents non-cooperation is the only stable coalition structure if there are more than two countries in the fishery*») [13].

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