North-South Climate Change Negotiations: a Sequential Game with Asymmetric Information

A. Caparrós, J.-C. Pereau and T. Tazdaït

NOTA DI LAVORO 9.2003

JANUARY 2003

CLIM – Climate Change Modelling and Policy

A. Caparrós, *CNRS-EHESS-CIRED, France*
J.-C. Pereau, *OEP, University of Marne-la-Vallée, France*
T. Tazdaït, *CNRS-EHESS-CIRED, France*

North-South Climate Change Negotiations: a Sequential Game with Asymmetric Information

Summary

This article determines the conditions under which the Southern countries should act together, or separately, while negotiating with the North about climate change policy and about the conditions for future Southern engagement. The paper models the international negotiations with complete and with asymmetric information in a dynamic framework. Results show that, depending on their characteristics, the different players can obtain benefits delaying the moment of the agreement.

Keywords: Bargaining theory, asymmetric information, climate change, international cooperation

JEL: C78, D74, H77

Address for correspondence:

A. Caparrós
CNRS-EHESS-CIRED
Jardin Tropical,
45 bis av de la belle Gabrielle
94736 Nogent sur Marne Cedex
France.
Phone: +33143947385
Fax: +33143947370
E-mail: caparros@centre-cired.fr

1 Introduction

In 1992 virtually all the countries of the world signed, and ratified, the United Nations Framework Convention on Climate Change whose ultimate objective is to achieve the 'stabilization of greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic inference with the climate system'. Five years later, the Kyoto Protocol was signed, engaging the countries included in Annex I (OECD and economies in transition) to reduce their overall emission by five per cent in 2012 compared to 1990. This agreement was afterwards further discussed and refined, and in 2001, almost all the countries of the world (with the only significant absence of the United States of America) agreed on the Marrakech Accords, which are expected to permit the Kyoto Protocol to come into force (this requires that countries accounting for 55% of Annex I carbon dioxide emissions ratify it[1]).

Although it is fair to acknowledge that the industrialized countries (IC) are the main historic, and present, causers of anthropogenic climate change, the solution of the problem will need the implication of the developing countries (DC) in a more comprehensive way than the one proposed in the Kyoto Protocol (based on projects). This is especially true if we assume that the DC will be able to develop as fast as they need. In fact, the incorporation of the DC is the main issue on the negotiation agenda and the absence of binding targets for the DC was one of the main arguments used by President Bush to reject the Kyoto Protocol.

In the next negotiation rounds we shall see the North (the Annex-I countries which have ratified the Kyoto Protocol) negotiating with the South (Non-Annex I countries) the most convenient way to bring them on board. The North, led by the European Union, has recognized its historical responsibility (in official texts but also accepting to be the first one to reduce) and should be ready to compensate in some way the South for accepting limitations to their urgently needed development. This compensation could take the form of monetary transfers but could also be based on other type of advantages.

Until now the DC have talked in the international climate change arena with a single voice, the so-called "G77 and China" group. Nevertheless, until now, the DC, although Parties of the negotiations, have not been affected by binding reductions and therefore somehow less involved in the "hard part" of the negotiations. In the new context, the Southern countries have to decide whether they continue to talk with a single voice or whether they split up into two or more groups (the G77 and China is a highly heterogeneous group, including small countries highly vulnerable to climate change and countries like Saudi Arabia strongly interested in oil exports). Talking together gives bargaining power, but under some circumstances, it may be more convenient to split up to take advantage of the internal differences. Rotillon et al. (1996) analysed this issue with complete information

[1] As well as 55 countries, including Annex I as well as Non-Annex I countries.

and particular benefit functions. Nevertheless, official statistics in the South are rare and incomplete and real knowledge about the abatement costs and options in the South are not at all available to the North. On the contrary, due to the high amount of existing studies, and due to the implementation of the Kyoto Protocol, the South will have almost complete information about the cost and benefit functions of the North. Hence, we discuss this issue in the context of asymmetric information and with general functional forms.

Finally, if the Southern countries decide to split up into two groups (e.g.), these groups can be *complementary* or *substitutable*. We call them *complementary* if the North needs to sign an agreement with both groups to be effective, and *substitutable* if an agreement with one of the groups is enough to produce positive benefits. At first glance, the Southern groups should be considered substitutable in the case of climate change since if one group, e.g. representing 50% of the Southern emissions, accepts to reduce its future emissions (or to increase them less) this will have a positive effect on climate change. Nevertheless, the opposite situation is also possible. As described above, in 1997 the Kyoto Protocol was signed, but stating that it will only come into force if countries representing 55% of Annex I emissions ratify it. This gave, especially after the withdrawal of the United States, Russia and other countries a lot of bargaining power since they became complementary. This situation might be repeated if an initial Protocol states that the DC will only be obliged to reduce their emission patterns if DC representing 55% (e.g.) of Non-Annex I emissions ratify it[2]. Hence, we discuss in our model the circumstances under which the South is interested in pushing for such a situation.

Another relevant characteristic of international negotiations, and in particular of the climate change negotiations, is that they take a great deal of time to conclude. In principle, if negotiators were efficient, we should expect them to finish in one single negotiation round. Nevertheless, the delay in the negotiations can be used, and has been used in the past, to take advantage and to gain better knowledge of the characteristics of the opponent. Therefore, we model the negotiations in a dynamic framework to analyse the circumstances under which the Parties benefit from delaying the agreement.

Game theory literature on cooperation in the context of climate change has followed two approaches[3], although both of them assimilate cooperation and coordination of environmental policies. On the one hand, we have what Tulkens (1998) called the thesis of the "little stable coalitions" (Carraro and Siniscalco, 1993; Barret, 1994; Péreau and Tazdaït, 2001; among others). On the other hand, we have the thesis of the "grand stable coalition" (Chander and Tulkens, 1997; Egteren and Tang, 1997; Funaki and Yamato, 1999; Helm, 2001; among others). According to the first approach, only a small number of countries will

[2]In fact, this kind of clause is common in international agreements.

[3]For a survey see Finus (2001).

accept to sign an agreement (the stability concept used comes from the analysis of cartels in industrial economics). In this framework, a coalition including all the countries is not sustainable since the benefits arising from cooperation are a public good (distributed to all countries), while the costs are borne only by the countries forming the coalition. On the contrary, in the second approach all the countries are interested in cooperation (taken individually or in sub-groups). According to Chander and Tulkens (1995, 1997) an agreement should not only be based on pareto optimality to be effective, but should also prevent any sub-group of countries to be interested in secession. Hence, the objective is to set up a burden-sharing rule able to favour the cooperation of all. However, these two approaches have in common that the negotiating process has been completely ignored, as well as significant characteristics like the information asymmetry, countries heterogeneity[4], or even the possibilities of renegotiation. In the non-cooperative games evoked by Carraro and Siniscalco, negotiation is modelled as simultaneous discourse, not leaving any space to dialogue (i.e. the possibility of carrying out counter-propositions). In the models of endogenous coalition formation (Chander and Tulkens, 1995, 1997), cooperation is the result of the direct intervention of a third party: a supranational authority acting as a central planner. This central planner is assumed to be good-willed, to defend the global interests and to have enforcement power; somehow irrealistic assumptions in the context of real climate change negotiations.

To overcome these limitations, we analyse future climate change negotiations in a dynamic framework, with asymmetric information, with heterogeneous coalitions and explicitly including the possibility to make counter-propositions. In technical terms, we develop a sequential game with asymmetric information in a bilateral, as well as in a multilateral framework. This model is set out using general functional forms and could therefore be applied to most of the current and future discussions between the North and the South; and, more generally, in all circumstances where negotiations take place between one player, whose characteristics are well known and who is ready to pay the other players to obtain something, and one or two players whose characteristics are only partially known.

The article is organised as follows. In section 2 we present the general model. In section 3, we analyse the outcomes of the game with complete information. The study of the negotiation with incomplete information is proposed in section 4. Finally, section 5 highlights the main conclusions.

[4]Most of the work with heterogeneous countries is based on numerical simulations (Barrett, 1997; Botteon and Carraro, 1997, 1998) and hence does not provide general results. The theoretical work available has been developed within the highly restricted framework of countries characterised by specific welfare functions (Hoel, 1992; Heal, 1994).

2 The model

We analyse a bargaining game between the North (Annex I countries which have ratified the Kyoto Protocol), which is assumed to be neutral to risk, and a group of developing countries (e.g. the G77 and China). The negotiation is about the value of the transfers that the North (N) will grant to countries of the South (S) willing to cooperate and commit themselves. The Southern countries are assumed to be identical and C in number. To assume identical countries could be seen as a limitation (see above); however, it is important to recall that we are assuming that all the countries of the Southern coalition talk with a single voice. Therefore, there is no problem in considering that a country like China has more votes (parts of C) in the internal vote (in fact, C could also refer to the amount of emissions as in the example described in the introduction). We call $0 < \delta_i < 1$ the discount rate of agent i, $i = N, S$. The benefit for the North is the difference between the abatement reached ($B(C) = B$), and the cost of the transfers to the C countries of the Southern coalition (τC):

$$\Pi(\tau, t) = \delta_N^t [B - \tau C] \tag{1}$$

The utility function of the Southern coalition is:

$$U(\tau, t) = \delta_S^t [(\tau - b)C] \tag{2}$$

We assume that the minimum amount of transfers (or other type of advantages) asked for by the Southern coalition (b) is decided in an internal vote among the coalition (as it occurs in the international negotiations, where G77 and China have private meetings where they decide their position). With this amount of transfers b the utility is zero. We also define the "reservation transfer", as the maximum transfer that the North can accept. This amount is given by the benefits that the North obtains from the reductions in the South (we assume that the negotiation is about the amount of transfers for a given level of Southern effort). The maximum transfer level is B/C, and the benefit for the North would be zero. That is, the negotiation area is bounded by b and B/C. Thus, for $B/C < b$, the agreement set is empty. To make the agreement possible, we suppose $B > Cb$. All the elements of the negotiation are known, except the minimum amount of transfers that is acceptable to the Southern group. This amount can have two possible values b^- or b^+, where $b^- < b^+ < B/C$. The Northern negotiator has an apriori probability function for these values: $p_N(b^+) = p^+$ and $p_N(b^-) = p^- = 1 - p^+$.

The players propose offers alternatively, which refer to the amount of transfers for a given effort. The negotiation goes on with no time limit. We call the game where the North (respectively the South) makes the first offer J_N^∞ (J_S^∞). Let us analyse the structure of the J_N^∞ game.

The North proposes an amount of transfers τ_N. The South accepts (Yes) or refuses (No) the proposition. If the South accepts an agreement is signed in the

first period. The objective functions of the agents are:

$$\Pi(\tau_N, 0) = B - \tau_N C \quad \text{and} \quad U(\tau_N, 0) = (\tau_N - b)C$$

If the South rejects the offer, the negotiation continues with a counter-offer from the South. If the North accepts this new offer, an agreement is signed in the second period, with an amount of transfers τ_S. Thus:

$$\Pi(\tau_S, 1) = \delta_N[B - \tau_S C] \quad \text{and} \quad U(\tau_S, 1) = \delta_S[(\tau_S - b)C]$$

Otherwise, the negotiation starts again with a Northern offer τ_N. In the case of an agreement:

$$\Pi(\tau_N, 2) = \delta_N^2[B - \tau_N C] \quad \text{and} \quad U(\tau_N, 2) = \delta_S^2[(\tau_N - b)C]$$

And so on. In the case of perpetual disagreement we get :

$$\Pi(\tau_0, \infty) < \Pi(\tau, t) \quad \text{and} \quad U(\tau_0, \infty) < U(\tau, t) \quad \text{for the final } t.$$

We assume that both agents have a given preference for the present. Hence, for two moments in time t and s, with $t < s$, we have:

$$\Pi(\tau, t) \geq \Pi(\tau, s) \quad \text{and} \quad U(\tau, t) \geq U(\tau, s)$$

with $\tau = b^-, b^+$. The inequality will be strict if $\Pi > 0$ (respectively $U > 0$). This time preference can be explained since there are no benefits for the two parts during the negotiations.

Since the acceptation of an offer closes the negotiation, an history in time t, h^t, describes a possible evolution of the negotiations from the beginning at date 0 until date t (including the behaviour in t). More precisely, it gives the sequence of propositions leading to a disagreement, if there were propositions, knowing that the North revises its believes taking into account the history. Call H the set of all the possible histories and H^t the set of all the possible histories with a duration t. A pure strategy for i is a function f_i where:

$$f_i^t \ : \ H_i^{t-1} \rightarrow [b^-, b^+] \cup (\text{Yes, No})$$

specifies after each history h_i^{t-1} $(\in H_i^{t-1})$ the behaviour of i at time t. In particular, it tells us if after h_i^{t-1}, i will propose a new offer, or refuse or accept the offer of j. Hence, a history is formed either by a proposition between b^- and b^+, or by a refusal or an acceptation. This last choice can only appear at t. The result of the negotiation will also depend upon the beliefs of the North. The resolution of the dynamic game with incomplete information is based on the concept of sequential equilibrium (Kreps et Wilson, 1982). By definition, a set of strategies and a family of beliefs form a sequential equilibrium if the following two conditions hold: (i) the strategies of both players are optimal in all the points of the game, given the believes of the North, and (ii) the beliefs of the North are Bayesian[5].

[5] We could also adopt a perfect bayesian equilibrium concept. However, as Kreps and Wilson

3 Complete information

3.1 Bilateral negotiation

Following a similar resolution method to the one proposed by Rubinstein (1982), we calculate the unique perfect equilibrium with complete information to which both players agree immediately in the first negotiation round (see Hovi (2001) for an alternative application of this methodology to the Clean Development Mechanism). The minimum amount of transfers b requested by S is supposed to be common knowledge. Let $\tau^*(N,S)$ be the equilibrium transfer when the North opens the negotiations and $\tau^*(S,N)$ the equilibrium transfer when it was proposed by the South[6]. We obtain:

$$\tau^*(N,S) = \frac{bC(1-\delta_S) + \delta_S(1-\delta_N)B}{(1-\delta_N\delta_S)C} \tag{3}$$

and

$$\tau^*(S,N) = \frac{B(1-\delta_N) + bC\delta_N(1-\delta_S)}{(1-\delta_N\delta_S)C} \tag{4}$$

Concerning the position of the players in the game, we can formulate the following corollary. It says that N (respectively S) prefers to play the game where it opens the negotiations (J_N^∞ , respectively J_S^∞), instead of the opposite where it responds (J_S^∞, respectively J_N^∞).

.

Corollary 1 If J_N^∞ and J_S^∞ are two games with perfect information, being b common knowledge, we obtain the following two expressions:

$$\begin{aligned} J_N^\infty &\succ {}_N J_S^\infty \\ J_S^\infty &\succ {}_S J_N^\infty \end{aligned}$$

Proof. We can see that:

$$\tau^*(S,N) > \tau^*(N,S) \Longleftrightarrow B > Cb$$

Since by definition $B > Cb$, the inequality always holds.
S wishes to obtain the highest amount of transfers and prefers the situation where $\tau = \tau^*(S,N)$, i.e. the amount of transfers that it obtains in the game where it talks first. On the contrary, N wishes to obtain the lowest amount of transfers and prefers the situation where $\tau = \tau^*(N,S)$, i.e. the amount of transfers that it obtains in the game where it talks first. ■

(1982) show, this concept has the drawback that it defines a great amount of solutions, while the sequential equilibrium permits to restrain them.

[6]These transfer equilibria are derived from a backward induction reasoning (Rubinstein, 1982).

3.2 Multilateral negotiation

Let us now consider the case where the South is organised in two separate groups, S_i, $i = 1, 2$, representing C_i countries, with $C_1 + C_2 = C$. The benefit obtained by the North from the abatement of group i is noted B_i, $i = 1, 2$. The aim is to study the union and disunity behaviours of the groups in complete information according to their degree of complementarity and substitutability. We assume that within each group, the members vote to determine their minimum level of transfer claims. Let b_i $(i = 1, 2)$ be the transfer requested by the group i (resulting from the internal vote within each group) and b the transfer requested by the groups while acting together (resulting from the internal vote within the group formed by both sub-groups).

The bargaining process has the same characteristics as previously described. The game consists in alternative offers and the North makes the initial offers (one to each group) If one group accepts the offer while the other refuses, the negotiation with the former group is finished; going on with the latter group. If both groups simultaneously refuse (accept), the negotiation keeps going on (ends) with both groups. This process goes on until an agreement is reached.

Let $0 < \delta_S < 1$ be the fixed discount rate of the groups (joined or separated). We have $\forall i = 1, 2$:

$$\tau^*(N, S_i) = \frac{b_i C_i (1 - \delta_S) + \delta_S (1 - \delta_N) B_i}{(1 - \delta_N \delta_S) C_i} \tag{5}$$

Both groups will accept to form a unique alliance if, by their cohesion, they reach a more satisfactory level than they would have reached acting separately:

$$U_1 + U_2 < U \tag{6}$$

where U_i is the utility of the groups $(\forall i = 1, 2)$. Condition (6) involves:

$$bC - b_1 C_1 - b_2 C_2 < B - B_1 - B_2 \tag{7}$$

Let us define $V_i = (B - bC) - (B_j - b_j C_j)$, $i \neq j$, the maximum contribution of group i to the benefit of the North. Condition (7) is rewritten as follows:

$$V_1 + V_2 > B - bC \tag{8}$$

The two Southern groups should act together when the North benefits from negotiating separately with each of them. This only happens if the distribution rule among the members of the Southern group allows them to obtain more together than what they would obtain separately. The North is only motivated to favour two bilateral negotiations if it intends to propose a low level of transfers. In this configuration, by standing separately, the bargaining power of the South is lower, as their threat to refuse any agreement is less credible. If one group tries to use

that threat, the North will propose a slightly more interesting offer to the other group. Being confronted with two distinct groups, it could propose a low level of transfers and take advantage of the disunity and lead both Southern groups to accept its offer. To foil that strategy, the two groups have to act together.

If condition (8) is not respected, the Southern groups should participate separately in the negotiations. In this case, the North is inclined to propose a high level of transfers from the beginning of the negotiation. Since the North proposes a high level of transfers, its intention is to conclude an agreement as soon as possible . Each group is therefore incited to take advantage of that situation by accepting the overbid game. The separation of the groups accentuates this behaviour and increases their bargaining power. Hence, we obtain the following proposition:

Proposition 1

1. *When $V_1 + V_2 > B - bC$, a unique subgame perfect equilibrium exists in which the groups act jointly.*

2. *When $V_1 + V_2 < B - bC$, a unique subgame perfect equilibrium exists in which the groups act separately.*

The outcome of the negotiations depends widely on the degree of commitment of the North. It defines the whole process of negotiations by making the first offer. If the Southern countries anticipate a moderated commitment, they will be united during the negotiations, since that will give them significant bargaining power. Conversely, if they anticipate a high commitment, they will be dissociated into two separate groups.

We will now analyse the behaviour of the Southern groups according to their degree of substitutability and complementarity. The groups are said complementary when the two groups have to sign the agreement so that benefits can arise (see introduction). They are called substitutable when the agreement can be reached with only one of the groups. If we accept perfect complementarity, an agreement signed by only one group has no impact. Therefore, $\forall C_i$, $i = 1, 2$, we have $V_1 = V_2 = 0$. Hence:

$$V_1 + V_2 < B - bC \tag{9}$$

Since relation (9) always holds for the complementary groups, we assume that they will act separately during negotiations. In this way both can unilaterally compromise the negotiations in case of disagreement. On the other hand, when the groups are substitutable, they had better act together to preserve their bargaining power. The following expression is found inverting equation 6:

$$V_1 + V_2 > B - bC \tag{10}$$

According to the North, the inequality (10) means that the maximum additional contribution to the Northern payoff of the two united groups is low. Thus, an agreement with one of the groups is enough. We obtain the following proposition:

Proposition 2

1. *When the two groups are perfectly complementary, they will act separately.*
2. *When the two groups are perfectly substitutable, they will act jointly.*

When the Southern groups are complementary; the North would like to negotiate with the united groups. Conversely, the Southern groups will adopt the asymmetric behaviour. Being complementary, they are aware of being the driving forces and that incites them to be dissociated into two distinct groups. Such behaviour gives them bargaining power and allows them to request a higher amount of transfers.

When the groups are substitutable; the North needs to conclude an agreement with only one of them. Conversely, the Southern groups are incited to act united to preserve their bargaining power. Nevertheless, that alliance is fragile since one of the groups can betray its partner accepting a slightly lower level of transfers, which guarantees the signing of an agreement.

4 One-sided incomplete information

4.1 Bilateral negotiation

We now analyse the game in which the North opens the negotiations and does not know the amount of transfers requested by the Southern countries. We might justify this situation as follows: the North has complete, easily accessible statistics, as well as a high amount of studies estimating the costs of climate change policy in the North. In addition, the North (formed by the IC which have ratified the Kyoto Protocol) will have started its climate change policy and revealed its reduction potentials. On the contrary, in most of the Southern countries statistics are incomplete and the knowledge about the cost of alternative climate change policies is not well known. Therefore, the South has better information about the amount of transfers that it can request compared to the information available to the North about the minimum level of transfers (or other benefits) that the South would accept.

To simplify, we assume that the amount transfers requested by the Southern group can only take two values: b^- or b^+, with $b^- < b^+ < B/C$. Either it is low, and we will call the group type b^-, or it is high and the group will be of type b^+. According to Harsanyi (1967), this game is formalised by introducing a

new player, Nature, which selects the group b^+ (respectively b^-) as the Northern opponent with probability p^+ (respectively $1-p^+$). The distribution of probability is common knowledge.

Since we use the concept of sequential equilibrium, we have to specify the form of the beliefs of the North. We will define pessimistic beliefs (Rubinstein, 1988). Hence, each time an event of probability zero appears, the North considers that it is facing b^+[7].

The relation $b^- < b^+ < B/C$ means that the North is in a position of strength faced with b^-, while it is in a position of weakness faced with b^+ (who has stronger transfer demands). Within the game in complete information, the equilibrium transfer issued from the negotiation with b^+ is higher or equal to the equilibrium transfer in the negotiation with b^-. Hence:

$$\tau^*(N, S^+) \geq \tau^*(N, S^-) \tag{11}$$

With one-sided incomplete information, b^- is interested in persuading the North that it has strong demands. Therefore, its strategy consists in adopting behaviour similar to b^+. Lemmas (1) to (4) show this result.

Lemma 1 If in any sequential equilibrium of the game J_N^∞, two types of Southern groups propose a counter-offer, they will make the same one. In this case, b^- is interested in suggesting a counter-offer identical to the one proposed by b^+.

Lemma 2 In any sequential equilibrium of J_N^∞ :

a) If b^- refuses a proposition τ_N, b^+ is interested in doing as well.

b) Conversely, if b^+ accepts a proposition τ_N, it is in the interest of b^- to do as well.

Lemma 3 In any sequential equilibrium of J_N^∞, a group, whatever its type, will accept any offer τ_N verifying:

$$\tau_N \geq (1 - \delta_S)b + \delta_S \tau^*(S^+, N) \tag{12}$$

As the range of possibilities of b^- is larger than the one of b^+, there are levels of transfer τ_N likely to be accepted by the first and refused by the second. The following lemma (4) confirms that.

Lemma 4 In any sequential equilibrium of J_N^∞, if:

$$(\tau^*(S^+, N) - b^-)\delta_S + b^- \leq \tau_N \tag{13}$$

[7]We retain that type of beliefs among the family of possible beliefs (optimistics, passives or continued) since they are the most economically relevant within this model.

b^- accepts the proposition τ_N while b^+ rejects it and offers $\tau^*(S^+, N)$, which will be accepted by N.

Lemmas (1) to (4) lead us to propositions (3) to (5) for the one-sided incomplete information game.

Proposition 3 *In any sequential equilibrium of the game J_N^∞ where the North is characterised by pessimistic beliefs and where equation (13) is verified, we obtain the following results :*

1. *If :*

$$p^+ < \frac{C[\tau^*(N, S^+) - \tau_N]}{B(1 - \delta_N) + C[\delta_N \tau^*(S^+, N) - \tau_N]} = g$$

   The North proposes the level of transfers τ_N. b^- accepts it while b^+ refuses it to make a counter-offer $\tau^*(S^+, N)$, accepted by the North.

2. *If $p^+ > g$, the North proposes the level of transfers $\tau^*(N, S^+)$ which is immediately accepted by the Southern groups whatever their type.*

3. *If $p^+ = g$, two cases are conceivable:*

   - Either the North proposes the transfer $\tau^*(N, S^+)$ which is immediately accepted by the Southern group, whatever its type.

   -Or it proposes the transfer τ_N verifying (13) but it is refused by b^+. The counter-offer of b^+ is then equal to $\tau^*(S^+, N)$ and is accepted by the North.

The results of this proposition show that the asymmetry of information totally favours b^- as it is incited to adopt opportunistic behaviour. The North can however determine the real characteristic of its opponent. For that, it just has to propose a transfer τ_N verifying (13) which will be a sufficient incentive for b^- to accept and give up the option of making a counter-offer. Nevertheless, since $\tau_N > \tau^*(N, S^-)$, b^-, although forced to reveal its characteristics, benefits from its opportunism. Let us add that the situation of the North is even more unfavourable if equation (13) is not verified. The following proposition illustrates this situation.

Proposition 4 *In any sequential equilibrium of the game J_N^∞ where the North is characterised by pessimistic beliefs and where the relation (13) is not verified, if the North opens the negotiations proposing $\tau^*(N, S^-)$, it will be refused by the Southern groups whatever their type.*

However, the asymmetry of information does not involve great consequences on the moment of signing of an agreement. The following proposition shows that an agreement will be rapidly obtained.

Proposition 5 *In any sequential equilibrium of the game J_N^∞ characterised by an asymmetry favourable to the Southern groups, the negotiations will never last more than two periods.*

This proposition is similar to the one developed by Osborne and Rubinstein (1990). The idea is as follows: Suppose an agreement is reached at the period n ($n \in \aleph^*$) on a proposition of the Southern group. Lemma (1) defines the behaviour of b^-. Its strategy consists in imitating the behaviour of b^+ by making the same counter-offer. Thus, whatever the type of group, the counter-offers will be $\tau^*(S^+, N)$. In addition, the North is not interested in prolonging the negotiations until the period n, since it can accept the transfer $\tau^*(S^+, N)$ at the second period, obtaining higher earnings due to its preference for the present. Hence, if a proposition τ_N is refused by both types of Southern groups, the agreement can only emerge at the following period.

On the contrary, if the offer of first period τ_N is accepted by b^-, the North can determine the real characteristics of its opponent. It will then make a counter-offer τ_S to b^+. The Southern group, not being able to rise the amount of transfers by means of its refusal, will accept τ_S. Thus, the negotiation will end at the second period.

Finally, if the offer τ_N is a sufficient incentive to be accepted by the two types of union, i.e. $\tau_N \geq \tau^*(N, S^+)$, the agreement will take place at the first period.

However, remark that this result is only valid for a situation where the incomplete information is reduced to two possibilities. If the problem gets more complicated, the agreement will no longer be reached at the second period.

Propositions (3) and (4) show that with asymmetry of information, two categories of agreements are likely to be signed. We can associate a sequential equilibrium to each of these types of agreements.

On the one hand, an agreement where b^+ accepts the equilibrium transfer obtained from the game without asymmetry of information is possible. The equilibrium transfers is $\tau^*(S^+, N)$ and b^- accepts the offer τ_N defined by (13). We call this sequential equilibrium 'separating'. The North is certain to determine the characteristic of the Southern group. By proposing the transfer τ_N, only b^- will accept it. In case of rejection, the North will suppose that its opponent is b^+.

On the other hand, an agreement concluded on a transfer corresponding to b^+, is highly profitable for b^-. This latter group obtains more than what it expected in complete information. We find here a 'pooling' sequential equilibrium. The agreement doesn't reflect the type of the contracting parties.

The importance of this second case depends strongly on the beliefs of the North. There is a monotonous relation between the value p^+ and the possible emergence of a pooling sequential equilibrium. The higher (lower) the initial belief p^+ of the North, the higher (lower) are the chances to meet an agreement with a transfer $\tau^*(N, S^+)$ from the first negotiation round. Therefore, if the Southern

group was able to emit in a pre-game phase a signal not corresponding to its type, the asymmetry could quickly favour them. Keeping personal information plays a essential role in the bargaining process.

Proposition (5) shows that time takes a new strategic dimension in the presence of asymmetry of information. In this case, time favours the Southern groups. We have seen that the strategy of b^- is to adopt opportunistic behaviour, by posting demands identical to the ones requested by b^+. This strategy allows it to emit a signal not corresponding to its own type. Furthermore, even if the negotiations continue, the North is not able to discover the real characteristic of the Southern group. Hence, to maintain the advantage granted by the asymmetry of information, b^- has to persevere and not change its strategy. Therefore, the North is not interested in prolonging the negotiations, since it will not be able to discover the real characteristics of its opponent. Taking into account the temporal dimension and its asymmetry of information, the North is encouraged to quickly conclude an agreement. Nevertheless, this configuration favours b^-. If the initial offer of the North is judged unsatisfactory, it will make a positive profit, equal to $\tau^*(S^+, N) - \tau_N$, since its counter-offer is higher than the one it would have requested in the absence of asymmetry of information. On the contrary, b^+ will receive a transfer corresponding to its characteristics (whatever the initial situation).

This proposition also shows that the asymmetry of information could prolong the negotiations, although an agreement is likely to be achieved at the second period. This delay is a consequence of the asymmetry of information, and corresponds to the time needed by the North to determine the type of the Southern group.

4.2 Multilateral negotiation

We now analyse a negotiation between the North and two distinct Southern groups S_1 and S_2. When the North is confronted with the group S_i $(i = 1, 2)$ the associated distribution of probability is written $P_{N_i}(b^+) = p_i^+$ and $P_{N_i}(b^-) = 1 - p_i^+$. In extension to proposition (3), we have:

$$g_i = \frac{C_i[\tau^*(N, S_i^+) - \tau_{Ni}]}{B_i(1 - \delta_N) + C_i[\delta_N \tau^*(S_i^+, N) - \tau^*(N, S_i^-)]} \quad i = 1, 2 \tag{14}$$

Since we focus on configurations involving a delay during the negotiation, we exclude the case where $p_i^+ > g_i$, $(i = 1, 2)$. When $p_i^+ < g_i$ $(i = 1, 2)$ three cases are conceivable according to the Southern groups' characteristics.

In the first configuration the group j is of type b_j^-, and the group k is of type b_k^+, $j \neq k$. Two sub-cases have to be considered. If both groups act together, they can claim either a transfer b^-, and obtain an agreement during the first stage, or a transfer b^+, which will extend the negotiation to the second period.

Sub-case 1. If acting together b_j^- and b_k^+ request b^-, they are interested in separating themselves if and only if:

$$U_j(\tau_{Nj}, 0) + U_k(\tau^*(S_k^+, N), 1) > U(\tau_N, 0) \tag{15}$$

That involves:

$$\begin{aligned} b_j^- &< \frac{(1-\delta_N\delta_S)(Cb^- - C_k b_k^+) - \delta_N(1-\delta_S)(Cb^+ - C_j b_j^+ - C_k b_k^+)}{(1-\delta_N\delta_S)C_j} \\ &- \frac{(1-\delta_N)(B - B_j - B_k)}{(1-\delta_N\delta_S)C_j} = \alpha_1 \end{aligned} \tag{16}$$

Sub-case 2. If acting together b_j^- and b_k^+ request b^+, they are interested in separating themselves if and only if:

$$U_j(\tau_{Nj}, 0) + U_k(\tau^*(S_k^+, N), 1) > U(\tau^*(N, S^+), 0) \tag{17}$$

Solving:

$$\begin{aligned} b_j^- &< \frac{(1-\delta_N\delta_S)(Cb^+ - \delta_S C_k b_k^+) - (1-\delta_S)(Cb^+ - \delta_N\delta_S C_j b_j^+ - \delta_N\delta_S C_k b_k^+)}{\delta_S(1-\delta_N\delta_S)C_j} \\ &- \frac{(1-\delta_N)(B - B_j - B_k)}{(1-\delta_N\delta_S)C_j} = \alpha_2 \end{aligned} \tag{18}$$

Since it can easily be shown that $\alpha_1 < \alpha_2$, for $b_j^- < \alpha_1$ whatever the claim of the union, the Southern groups favour disunity. For sub-case 1, b_k^+ is confronted with a delay while the union would lead to an agreement from the first stage. That delay represents the necessary time for b_k^+ to separate itself from b_j^- and reveal its demands to the North. For the latter, these demands reveal the characteristics of b_k^+ only if it has previously determined the type of b_j^-. b_k^+ would prefer disunity if it would obtain a higher benefit by showing its type. That requires that b_j^- concludes an agreement on a low level of transfers in the first period.

For sub-case 2, the negotiation delay is less costly for b_k^+ than in the previous case, since the delay would also appear acting together. Two simultaneous interpretations of the delay are possible. In the case of united groups, the delay represents the time needed by the North to infer the type of coalition it is confronted by. For the case of disunity, it describes the necessary time for b_k^+ to be dissociated from b_j^-. The sub-cases (1) and (2) correspond to a situation where the groups are complementary. This configuration reinforces the bargaining power of b_k^+. When it realizes that b_j^- wishes to demand a low transfer, it is interested in extending the negotiation to obtain a higher level of transfers in the second period.

When the inequalities (16) and (18) are inverted, we end up with a situation where the Southern groups are substitutable and act together. For the symmetric

sub-case (1), despite union, the negotiation goes on. The common action does not give a sufficiently dissuasive bargaining power to end the negotiation in the first round. The bargaining power of the union is compensated by the presence of the asymmetry of information, since the North uses the delay to determine the characteristics of the Southern group. Although the agreement is signed with the transfer $\tau^*(S^+, N)$, the union is confronted with a negotiation cost. In the case of complete information, an agreement with a transfer $\tau^*(N, S^+)$ would be signed in the first period.

In the second configuration, we assume that the Southern group j is of type b_j^+ and the group k of type b_k^+. In this case the negotiation will end in the second period even if there is no union. Disunity is favourable to the Southern groups if :

$$U_j(\tau^*(S_j^+, N), 1) + U_k(\tau^*(S_k^+, N), 1) > U(\tau^*(S^+, N), 1) \tag{19}$$

Solving:

$$b_k^+ < \frac{B_j + B_k - B + Cb^+ - C_j b_j^+}{C_k} \tag{20}$$

Equation (20) corresponds to the condition of complementarity (7). It shows that each group is interested in acting separately when their respective demands, although high, are not enough to take a relevant part of the benefit. Despite their complementarity, each group has room to manoeuver until a certain level. If this level is exceeded, the situation leads the groups to unite to obtain the bargaining power allowing them to reach an agreement based on a high level of transfers. This situation is associated to substitutability between the groups. In both cases, we find the initial interpretation of the negotiation delay. The delay becomes profitable to the North, it helps it to infer the characteristics of each group or the union of groups.

Finally, in the third configuration, we suppose that the group j is of type b_j^- and the group k of type b_k^-. The delay can take place when the groups act jointly and require b^+. Disunity is profitable if:

$$U_j(\tau_{Nj}, 0) + U_k(\tau_{Nk}, 0) > U(\tau^*(S^+, N), 1) \tag{21}$$

Solving:

$$\begin{aligned} b_k^- \quad < \quad & \frac{(1 - \delta_N \delta_S)(Cb^+ - C_j b_j^-) - \delta_N (1 - \delta_S)(Cb^+ - C_j b_j^+ - C_k b_k^+)}{(1 - \delta_N) C_k} \\ - \quad & \frac{(B - B_j - B_k)}{C_k} \end{aligned} \tag{22}$$

The Southern groups will favour disunity within a complementarity framework when their minima individual demands are low. That will incite them to accept

the offer of the North. Acting together their transfer demands are increased due to their strong bargaining power. Therefore, they are interested in extending the negotiation. Thus, the delay can be interpreted as the means to affirm high demands. The negotiation costs can be compensated by the anticipated higher benefit in terms of transfers. Hence, the groups characterised by low minimum demands are willing to claim more by being united.

We now focus on a situation in which the beliefs of the North lead to a separating equilibrium with one of the Southern groups and to a pooling equilibrium with the other, i.e. $p_j^+ > g_j$ and $p_k^+ < g_k$, $j \neq k$. In this situation, group j (whatever its characteristics) will accept the offer $\tau^*(N, S_j^+)$ at the first round. Its utility is written:

$$\begin{aligned} U_j(\tau^*(N, S_j^+), 0) &= [\tau^*(N, S_j^+) - b_j^-]C_j \quad \text{if } S_j \text{ is of type } b_j^- \qquad (23) \\ U_j(\tau^*(N, S_j^+), 0) &= [\tau^*(N, S_j^+) - b_j^+]C_j \quad \text{if } S_j \text{ is of type } b_j^+ \qquad (24) \end{aligned}$$

The utility of group k is:

$$\begin{aligned} U_k(\tau_{Nk}, 0) &= [\tau_{Nk} - b_k^-]C_k \quad \text{if } S_k \text{ is of type } b_k^- \qquad (25) \\ U_k(\tau^*(S_k^+, N), 1) &= \delta_S[\tau^*(S_k^+, N) - b_k^+]C_k \quad \text{if } S_k \text{ is of type } b_k^+ \qquad (26) \end{aligned}$$

The situations (23)+(25) and (23)+(26) are included in the cases previously discussed. For the remaining situations, we limit ourselves to those in which the negotiation delay appears. The situation (24)+(25) leads to the following relation:

$$U_j(\tau^*(N, S_j^+), 0) + U_k(\tau_{Nk}, 0) > U(\tau^*(S^+, N), 1) \qquad (27)$$

For

$$\begin{aligned} b_k^- < & \frac{(1-\delta_N\delta_S)(\delta_S C b^+ - C_j b_j^+) - (1-\delta_S)(\delta_N\delta_S C b^+ - C_j b_j^+ - \delta_N\delta_S C_k b_k^+)}{\delta_S(1-\delta_N\delta_S)C_k} \\ & - \frac{(1-\delta_N)(B - B_j - B_k)}{(1-\delta_N\delta_S)C_k} \end{aligned} \qquad (28)$$

b_j^+ and b_k^- will tackle the negotiations separately. When the Southern groups are complementary and their individual demands high, they are willing to act separately. On the other hand, when they are substitutable, they will act jointly and force the negotiation delay because the beliefs of the North lead it to make a low opening proposition.

Let us now analyse the situation (24)-(26). Two cases are conceivable according to the response of the union to the initial proposition of the North:

$$U_j(\tau^*(N, S_j^+), 0) + U_k(\tau^*(S_k^+, N), 1) > U(\tau^*(N, S^+), 0) \qquad (29)$$

or

$$U_j(\tau^*(N, S_j^+), 0) + U_k(\tau^*(S_k^+, N), 1) > U(\tau^*(S^+, N), 1) \tag{30}$$

These two configurations lead to the same condition:

$$b_k^+ < \frac{B_j + B_k - B + Cb^+ - C_j b_j^+}{C_k} \tag{31}$$

Thus, although b_k^+ bears a negotiation delay, disunity is still favoured. In the first case, the complementarity allows b_k^+ to affirm its demands by refusing the initial offer of the North. Therefore the delay allows b_k^+ to obtain what it expected. However, when they are substitutable, b_k^+ is interested in joining b_j^+ to increase its bargaining power and not to bear a delay. In the second case, the Southern groups also favour disunity instead of union. Moreover, complementarity favours b_j^+ since it is induced to sign an agreement as of the first period, whilst, being united or acting separately, b_k^+ is still confronted with a delay.

To resume, the different configurations analysed lead to the following results: in the presence of asymmetric information, when the Southern groups form a union (when they are substitutable) the delay favours the North. That delay corresponds to the time necessary for it to acquire the relevant information concerning the demands of the groups. On the other hand, when the Southern groups act separately (complementarity situation), the delay has several interpretations. If one of the two Southern groups is of the type b^+, while the other is of type b^-, the delay corresponds to the time necessary for b^+ to dissociate from b^-. When both groups are of type b^+, the delay is used by one and/or the other group to affirm its transfer demands.

The comparison of equilibrium in complete and incomplete information in the multilateral negotiations game gives the following proposition:

Proposition 6 *When both groups are of type b_i^+, the conditions of complementarity-substitutability in presence of asymmetric information are identical to those obtained with complete information. On the contrary, when the groups have not the same transfer demands, the conditions of complementarity (substitution) are wider (more restrictive).*

Within a multilateral negotiation with incomplete information, the existence of an information asymmetry reinforces the bargaining power of complementary groups and reduces the power of substitutable groups. As with complete information, the complementarity, requiring the agreement of both groups, gives them a significant bargaining power compelling the North to propose a high level of transfers. In this context, the one and/or the other Southern group will take

advantage of its private information to increase its bargaining power and obtain an agreement on a high transfer level. The advantages of complementarity are therefore reinforced by the lack of information of the North. The asymmetry of information makes the conditions of complementarity obtained with complete information less restrictive. On the contrary, in the presence of substitutable groups, the North is interested in acquiring information on the characteristics of the groups, in order to oppose them by searching an agreement with only one of them. The possible race downwards leads the Southern groups to reveal their private information reducing their bargaining power. The drawbacks of the substitutability are reinforced by the informational asymmetry since, if the Southern groups request high transfers, the negotiations cannot be concluded in the first period. Thus, the conditions of substitutability are more restrictive than with complete information.

Considering these results, the South will be interested in repeating the pattern of the Kyoto Protocol. That is, the relatively rapid signing of a general agreement which makes the Southern groups complementary, followed by a discussion about the details (the Marrakech Accords in the case of the Kyoto Protocol) where the separation in two complementary groups will give them strong bargaining power to tackle the negotiations on the precise amount of the transfers.

Moreover, if both Southern groups have high demands, either complementary of substitute, they will never accept less than what they would obtain in complete information. Likewise, the North will never offer more than the maximum amount of transfers that it would have proposed with complete information. As an agreement is only reached with a transfer level corresponding to the demands of the Southern groups, the presence of asymmetry of information does not benefit them. Under these circumstances, the conditions of complementarity-substitutability are identical with complete and incomplete information.

5 Conclusion

The objective of this paper has been to determine the different forms that the international agreements to enlarge the Kyoto Protocol to include the developing countries might take. The main characteristics of the negotiation are the presence of asymmetry of information about the capacities of the South to reduce their emissions and the possibility to make the negotiations last more than one round. Although we have analysed the climate change negotiations, the framework developed is wide enough to represent most of the international negotiations between the North and the South, as long as they deal with an issue where the North is willing to transfer money (or other economic advantages) in exchange of some commitment by the Southern countries; and as long as available data about the North are more accurate than data about the South.

In a bilateral framework, we have shown that asymmetry of information is not

always beneficial for the developing countries coalition. The industrial countries will be interested in continuing the negotiations and may delay the moment of an agreement to obtain information about the characteristics of the Southern coalition. Compared to the outcome with complete information, the developing countries will pay a negotiation cost due to the delay.

In a multilateral framework, the information asymmetry reinforces the negotiation power of the complementary coalitions, which will generally act separately, and reduces that of the substitutable coalitions, which will generally act together. Hence, the developing countries are interested in forcing a situation where they are complementary by setting at an early stage (pre-game) of the negotiations a high minimum level of ratifications for the agreement to come into force (as it was done for the Kyoto Protocol). If the southern coalitions manage to become complementary, they will act separately but the agreement will not be reached in the first negotiation period. The delay can now be interpreted as the time needed by the coalition with strong demands to dissociate from the coalition with weak demands.

APPENDIX

Proof of lemma 1

See Rubinstein (1985). Nevertheless, the general principle of the demonstration is as follows. Let us consider the history for which b^+ and b^- reject the offer of N and suggest different offers in return. Let $\tau^*(S^+, N)$ be the offer of b^+ and τ_S^- the one of b^-, with:

$$B/C \geq \tau^*(S^+, N) > \tau_S^- > \tau^*(S^-, N) \tag{32}$$

After the Southern group has made its proposition, N is able to determine the characteristics of its opponent.

- Behaviour of N towards b^+. Faced with a proposition $\tau^*(S^+, N)$, N identifies its opponent as being b^+. Knowing that it could not propose less than $\tau^*(N, S^+)$ at the next period, it will accept the counter-offer. By offering the transfer $\tau^*(N, S^+)$, its benefit is not increased compared to that which it would obtain accepting $\tau^*(S^+, N)$ a period later.

- Behaviour of N towards b^-. Two cases are possible:

Observing τ_S^- verifying (32) and therefore strictly lower to $\tau^*(S^+, N)$, N knows that it is confronted with b^-. It just has to propose in the following period $\tau_S^- - \epsilon > \tau^*(S^-, N)$, with $\epsilon \to 0$ in a way that $\Pi(\tau_S^-, t) < \Pi(\tau_S^- - \epsilon, t+1)$. That strategy is profitable as it can improve its benefit. On the other hand, it deteriorates simultaneously the utility of b^-.

Suppose now that N accepts τ_S^-. b^- is then incited to deviate as it knows that N will also accept $\tau^*(S^+, N)$. Since both offers τ_S^- and $\tau^*(S^+, N)$ can be accepted, b^- is interested in requesting $\tau^*(S^+, N)$. $\square$

Proof of lemma 2

For each of these two cases, we consider the game at any date t where the Southern group is the proposer.

- b^- makes an offer τ_S different from τ_N if the utility associated to its proposition τ_S is strictly higher to the one obtained with τ_N. However, the lemma 1 stipulates that the counter-offer of b^- is equal to $\tau^*(S^+, N)$. The condition is then written:

$$U(\tau_N, t-1) \leq U(\tau^*(S^+, N), t)$$

or

$$C(\tau_N - b^-)\delta_S^{t-1} \leq C(\tau^*(S^+, N) - b^-)\delta_S^t$$

or

$$\tau_N - [(1-\delta_S)b^- + b^+\delta_S] \leq (\tau^*(S^+, N) - b^+)\delta_S$$

- Since $b^+ \geq (1-\delta_S)b^- + b^+\delta_S$, we obtain : $C(\tau_N - b^+) \leq C(\tau^*(S^+, N) - b^+)\delta_S$. Thus, when b^- refuses τ_N, b^+ does as much.

- Suppose b^+ accepts a proposition τ_N. Hence:

$$U(\tau_N, t-1) \geq U(\tau^*(S^+, N), t)$$

or

$$\tau_N - [b^-\delta_S + (1-\delta_S)b^+] \geq (\tau^*(S^+, N) - b^-)\delta_S$$

Since $b^- \leq b^-\delta_S + (1-\delta_S)b^+$, we have $C(\tau_N - b^-) \geq C(\tau^*(S^+, N) - b^-)\delta_S$. □

Proof of lemma 3

Suppose the Southern group does not accept τ_N. The lemma (1) tells us that the two types of groups will suggest the same counter-offer τ_S, with $\tau_S \geq b^+$. However, the highest proposition the Southern group can make is $\tau^*(S^+, N)$. Hence, for any transfer τ_N verifying the relation $\tau_N \geq (1-\delta_S)b + \delta_S\tau^*(S^+, N)$,we have $\tau_N - b \geq (\tau^*(S^+, N) - b)\delta_S$. Therefore, the Southern group will accept the transfer τ_N.

Let us precise the expression of the offer τ_N according to the type of the Southern group. If the group is type b^-, we have, for $b = b^-$: $\tau_N^- \geq (1-\delta_S)b^- + \delta_S\tau^*(S^+, N)$ and for $b = b^+ : \tau_N^+ \geq (1-\delta_S)b^+ + \delta_S\tau^*(S^+, N) = \tau^*(N, S^+)$.

Thus, although b^- is incited to behave like b^+ (according to lemma 1 and 2), it will benefit from a larger room of manoeuvre than b^+ (according to lemma 3). I.e., its set of satisfactory propositions is wider than the one of b^+:

$$\begin{aligned} \tau_N^- \in A &= [(1-\delta_S)b^- + \delta_S\tau^*(S^+, N), B/C] \\ \tau_N^+ \in B &= [(1-\delta_S)b^+ + \delta_S\tau^*(S^+, N), B/C] \end{aligned}$$

and $B \subset A$. For $\delta_S \to 1$, we have $\tau = B/C$. The behaviour of the Southern groups b^- and b^+, coincides when b^- is patient as they request both the highest wage that N can accept. Patience allows b^- to claim the requests of b^+. On the other hand, if b^- is impatient, its transfer demand becomes its reference transfer for the negotiation. □

Proof of lemma 4

We successively present the behaviours of b^-, b^+ and N.:

- Behaviour of b^-:

b^- will accept τ_N if that transfer level incites it to renounce, at the next period, to earnings associated to a proposition $\tau^*(S^+, N)$. It is enough that:

$$U(\tau_N, t-1) \geq U(\tau^*(S^+, N), t)$$

or

$$\tau_N - b^- \geq (\tau^*(S^+, N) - b^-)\delta_S$$

Due to its preference for the present, we have:

$$\tau_N \geq (\tau^*(S^+, N) - b^-)\delta_S + b^- \tag{33}$$

- Behaviour of b^+:

If b^+ prefers τ_S to τ_N, the following inequality has to hold:

$$U(\tau_N, t-1) < U(\tau^*(S^+, N), t) \tag{34}$$

or

$$\tau_N < \tau^*(N, S^+) \tag{35}$$

- Behaviour of two types of groups:

According to equation (33), b^- is not interested in refusing the offer τ_N since it will not increase its payoffs by a counter-proposition $\tau^*(S^+, N)$. On the contrary, according to (34), b^+ refuses τ_N since it can enhance its utility by proposing $\tau^*(S^+, N)$. Thus, for an offer τ_N verifying the condition (13), b^- has to accept it while b^+ can refuse it to propose afterwards $\tau^*(S^+, N)$.

- Behaviour of N:

If b^- accepts the offer of τ_N while b^+ rejects it to propose afterwards $\tau^*(S^+, N)$, N is able to determine the type of its opponent. In fact, it knows that for a level of transfers τ_N, verifying (34), b^- should not reject it (while b^+ should). N, knowing the type of group it is negotiating with, will accept the offer $\tau^*(S^+, N)$. □

Proof of proposition 3

- If N opens the negotiations on an offer $\tau^*(N, S^+)$, its expected payoff is:

$$\begin{aligned} E\Pi^+ &= p^+[B - \tau^*(N, S^+)C] + (1 - p^+)[B - \tau^*(N, S^+)C] \\ &= B - \tau^*(N, S^+)C \end{aligned} \tag{36}$$

On the other hand, if it suggests the pure strategy τ_N verifying (13), its expected payoff becomes:

$$E\Pi^- = (1 - p^+)[B - \tau_N C] + p^+\delta_N[B - \tau^*(S^+, N)C]$$

According to lemma (4), the offer will be accepted by b^- and rejected by b^+. This latter will propose the transfer $\tau^*(S^+, N)$, which will be accepted by N in the second period. The strategy τ_N is optimal for N if and only if: $E\Pi^- > E\Pi^+$ (the condition 1 of proposition (3)).

- If $E\Pi^- < E\Pi^+$, we are in the configuration where proposing $\tau^*(N, S^+)$ is optimal for N. Since that is the highest transfer that the Southern group can obtain in negotiations in complete information, it will accept it whatever its type.

- If $E\Pi^- = E\Pi^+$, the sequential equilibrium consists for N in adopting the mixed strategy $\tau^*(N, S^+)$ with the probability α and the strategy $\tau^*(N, S^-)$ with the probability $1 - \alpha$ with $\alpha \in [0, 1]$. b^+ will accept the proposition if it is at least equal to $\tau^*(N, S^+)$ while b^- will accept in the first period any proposition verifying (13). $\square$.

Proof of proposition 4

Since (13) is not verified, for $\tau_N = \tau^*(N, S^-)$, the expected payoff of N is written :

$$E\Pi^* = (1 - p^+)[B - \tau^*(N, S^-)C] + p^+\delta_N[B - \tau^*(S^+, N)C]$$

By comparing the expected payoffs associated to each strategy, we obtain the searched result $\square$

REFERENCES

Barrett, S. (1994). 'Self Enforcing International Environmental Agreements', *Oxford Economic Papers,* vol. 46, pp. 878-894.

Barrett, S. (1997). 'Heterogeneous International Environmental Agreements' in C. Carraro (ed.) *International Environmental Negotiations. Strategic Policy Issues.* Cheltenham: Edward Elgar.

Botteon, M. and C. Carraro (1997). Burden-Sharing and Coalition Stability in Environmental Negotiations with Asymmetric Countries. In C. Carraro (ed.), International Environmental Negotiations. Strategic Policy Issues. Cheltenham: Edward Elgar.

Botteon, M. and C. Carraro (1998). Environmental Coalitions with Heterogeneous Countries: Burden-Sharing and Carbon Leakage in A. Ulph (ed.) *Environmental Policy, International Agreements and International Trade.* Oxford: Oxford University Press.

Carraro, C. and D. Siniscalco (1993). Strategies for the International Protection of the Environment. *Journal of Public Economics*, vol. 2, pp. 309-328.

Chander, P. and H. Tulkens (1995). A Core-Theoretic for the Design of Cooperative Agreements on Transfrontier Pollution. *International Tax and Public Finance*, vol. 2, pp. 279-294.

Chander, P. and H. Tulkens (1997). The Core of an Economy With Multilateral Environmental Externalities. *International Journal of Game Theory*, vol. 26, pp. 379-401.

Egteren, H. and J. Tang (1997). 'Maximum Victim Benefit: A Fair Division Process in Transboundary Pollution Problems', *Environmental and Resources Economics*, vol. 10, pp. 363-386.

Finus, M. (2001). *Game Theory and International Environmental Cooperation* Edward Elgar: Cheltenham.

Funaki, Y. and T. Yamato (1999). 'The Core of an Economy with a Common Pool Resource: A Partition Function Approach', *International Journal of Game Theory*, vol. 28, pp. 157-171.

Harsanyi J., (1967-68). 'Games with Incomplete Information played by Bayesian Players', *Management Science*, vol 14, pp. 159-82, 320-34, 486-502.

Heal, G. (1994). 'Formation of International Agreements' in C. Carraro (ed.) *Trade, Innovation, Environment.* Dordrecht: Kluwer Academic Press.

Helm, C. (2001). 'On the existence of a cooperative solution for a coalitional game with externalities', *International Journal of Game Theory*, vol. 30 (1), pp. 141-146.

Hoel, M. (1992). 'International Environment Convention: The Case of Uniform Reductions of Emissions'. *Environmental and Resource Economics*, vol. 2, pp. 141-159.

Hovi, J. (2001). 'Decentralized enforcement, sequential bargaining, and the Clean Development Mechanism'. *CICERO Working Paper* 2001-12.

Kreps, D. and R. Wilson (1982). 'Sequential Equilibria', *Econometrica*, vol. 50, pp. 863-984.

Osborne, M. and A. Rubinstein (1990). *Bargaining and Market*, Academic Press.

Péreau, J.-C. and T. Tazdaït (2001). Cooperation and Unilateral Commitment in the Presence of Global Environmental Problems. *Environmental and Resource Economics*, vol. 20, pp. 225-239.

Rotillon, G., T. Tazdaït and S. Zeghni (1996). 'Bilateral or multilateral bargaining in the face of global environmental change?', *Ecological Economics*, vol. 18, pp. 177-187.

Rubinstein, A. (1982). 'Perfect Equilibrium in a Bargaining Model', *Econometrica*, vol. 50, pp. 97-109.

Rubinstein, A. (1985). 'A Bargaining Model with Incomplete Information about Time Preferences', *Econometrica*, vol. 53, pp. 1151-72.

Rubinstein, A. (1988). 'Choice of Conjectures in a Bargaining Game with Incomplete Information' in Alvin E. Roth (ed.) *Game Theoretic Models of Bargaining*, Cambridge University Press.

Tulkens, H. (1998). Cooperative vs. Free Riding in International Environmental Affairs: Two Approaches, in N. Hanley and H. Folmer (eds.) *Game Theory and the Environment*, London: Edward Elgar.

NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI
Fondazione Eni Enrico Mattei Working Paper Series
Our working papers are available on the Internet at the following addresses:
http://www.feem.it/web/activ/_wp.html
http://papers.ssrn.com

SUST	1.2002	*K. TANO, M.D. FAMINOW, M. KAMUANGA and B. SWALLOW*: Using Conjoint Analysis to Estimate Farmers' Preferences for Cattle Traits in West Africa
ETA	2.2002	*Efrem CASTELNUOVO and Paolo SURICO*: What Does Monetary Policy Reveal about Central Bank's Preferences?
WAT	3.2002	*Duncan KNOWLER and Edward BARBIER*: The Economics of a "Mixed Blessing" Effect: A Case Study of the Black Sea
CLIM	4.2002	*Andreas LÖSCHEL*: Technological Change in Economic Models of Environmental Policy: A Survey
VOL	5.2002	*Carlo CARRARO and Carmen MARCHIORI*: Stable Coalitions
CLIM	6.2002	*Marzio GALEOTTI, Alessandro LANZA and Matteo MANERA*: Rockets and Feathers Revisited: An International Comparison on European Gasoline Markets
ETA	7.2002	*Effrosyni DIAMANTOUDI and Eftichios S. SARTZETAKIS*: Stable International Environmental Agreements: An Analytical Approach
KNOW	8.2002	*Alain DESDOIGTS*: Neoclassical Convergence Versus Technological Catch-up: A Contribution for Reaching a Consensus
NRM	9.2002	*Giuseppe DI VITA:* Renewable Resources and Waste Recycling
KNOW	10.2002	*Giorgio BRUNELLO*: Is Training More Frequent when Wage Compression is Higher? Evidence from 11 European Countries
ETA	11.2002	*Mordecai KURZ, Hehui JIN and Maurizio MOTOLESE*: Endogenous Fluctuations and the Role of Monetary Policy
KNOW	12.2002	*Reyer GERLAGH and Marjan W. HOFKES:* Escaping Lock-in: The Scope for a Transition towards Sustainable Growth?
NRM	13.2002	*Michele MORETTO and Paolo ROSATO*: The Use of Common Property Resources: A Dynamic Model
CLIM	14.2002	*Philippe QUIRION*: Macroeconomic Effects of an Energy Saving Policy in the Public Sector
CLIM	15.2002	*Roberto ROSON*: Dynamic and Distributional Effects of Environmental Revenue Recycling Schemes: Simulations with a General Equilibrium Model of the Italian Economy
CLIM	16.2002	*Francesco RICCI* (l): Environmental Policy Growth when Inputs are Differentiated in Pollution Intensity
ETA	17.2002	*Alberto PETRUCCI*: Devaluation (Levels versus Rates) and Balance of Payments in a Cash-in-Advance Economy
Coalition Theory Network	18.2002	*László Á. KÓCZY* (liv)*:* The Core in the Presence of Externalities
Coalition Theory Network	19.2002	*Steven J. BRAMS, Michael A. JONES and D. Marc KILGOUR* (liv): Single-Peakedness and Disconnected Coalitions
Coalition Theory Network	20.2002	*Guillaume HAERINGER* (liv): On the Stability of Cooperation Structures
NRM	21.2002	*Fausto CAVALLARO and Luigi CIRAOLO:* Economic and Environmental Sustainability: A Dynamic Approach in Insular Systems
CLIM	22.2002	*Barbara BUCHNER, Carlo CARRARO, Igor CERSOSIMO and Carmen MARCHIORI*: Back to Kyoto? US Participation and the Linkage between R&D and Climate Cooperation
CLIM	23.2002	*Andreas LÖSCHEL and ZhongXIANG ZHANG:* The Economic and Environmental Implications of the US Repudiation of the Kyoto Protocol and the Subsequent Deals in Bonn and Marrakech
ETA	24.2002	*Marzio GALEOTTI, Louis J. MACCINI and Fabio SCHIANTARELLI*: Inventories, Employment and Hours
CLIM	25.2002	*Hannes EGLI:* Are Cross-Country Studies of the Environmental Kuznets Curve Misleading? New Evidence from Time Series Data for Germany
ETA	26.2002	*Adam B. JAFFE, Richard G. NEWELL and Robert N. STAVINS*: Environmental Policy and Technological Change
SUST	27.2002	*Joseph C. COOPER and Giovanni SIGNORELLO*: Farmer Premiums for the Voluntary Adoption of Conservation Plans
SUST	28.2002	*The ANSEA Network*: Towards An Analytical Strategic Environmental Assessment
KNOW	29.2002	*Paolo SURICO*: Geographic Concentration and Increasing Returns: a Survey of Evidence
ETA	30.2002	*Robert N. STAVINS:* Lessons from the American Experiment with Market-Based Environmental Policies

NRM	31.2002	*Carlo GIUPPONI and Paolo ROSATO:* Multi-Criteria Analysis and Decision-Support for Water Management at the Catchment Scale: An Application to Diffuse Pollution Control in the Venice Lagoon
NRM	32.2002	*Robert N. STAVINS*: National Environmental Policy During the Clinton Years
KNOW	33.2002	*A. SOUBEYRAN and H. STAHN* : Do Investments in Specialized Knowledge Lead to Composite Good Industries?
KNOW	34.2002	*G. BRUNELLO, M.L. PARISI and Daniela SONEDDA:* Labor Taxes, Wage Setting and the Relative Wage Effect
CLIM	35.2002	*C. BOEMARE and P. QUIRION* (lv): Implementing Greenhouse Gas Trading in Europe: Lessons from Economic Theory and International Experiences
CLIM	36.2002	*T.TIETENBERG* (lv): The Tradable Permits Approach to Protecting the Commons: What Have We Learned?
CLIM	37.2002	*K. REHDANZ and R.J.S. TOL* (lv): On National and International Trade in Greenhouse Gas Emission Permits
CLIM	38.2002	*C. FISCHER* (lv): Multinational Taxation and International Emissions Trading
SUST	39.2002	*G. SIGNORELLO and G. PAPPALARDO:* Farm Animal Biodiversity Conservation Activities in Europe under the Framework of Agenda 2000
NRM	40.2002	*S .M. CAVANAGH, W. M. HANEMANN and R. N. STAVINS:* Muffled Price Signals: Household Water Demand under Increasing-Block Prices
NRM	41.2002	*A. J. PLANTINGA, R. N. LUBOWSKI and R. N. STAVINS:* The Effects of Potential Land Development on Agricultural Land Prices
CLIM	42.2002	*C. OHL* (lvi): Inducing Environmental Co-operation by the Design of Emission Permits
CLIM	43.2002	*J. EYCKMANS, D. VAN REGEMORTER and V. VAN STEENBERGHE* (lvi): Is Kyoto Fatally Flawed? An Analysis with MacGEM
CLIM	44.2002	*A. ANTOCI and S. BORGHESI* (lvi): Working Too Much in a Polluted World: A North-South Evolutionary Model
ETA	45.2002	*P. G. FREDRIKSSON, Johan A. LIST and Daniel MILLIMET* (lvi): Chasing the Smokestack: Strategic Policymaking with Multiple Instruments
ETA	46.2002	*Z. YU* (lvi): A Theory of Strategic Vertical DFI and the Missing Pollution-Haven Effect
SUST	47.2002	*Y. H. FARZIN*: Can an Exhaustible Resource Economy Be Sustainable?
SUST	48.2002	*Y. H. FARZIN*: Sustainability and Hamiltonian Value
KNOW	49.2002	*C. PIGA and M. VIVARELLI*: Cooperation in R&D and Sample Selection
Coalition Theory Network	50.2002	*M. SERTEL and A. SLINKO* (liv): Ranking Committees, Words or Multisets
Coalition Theory Network	51.2002	*Sergio CURRARINI* (liv): Stable Organizations with Externalities
ETA	52.2002	*Robert N. STAVINS*: Experience with Market-Based Policy Instruments
ETA	53.2002	*C.C. JAEGER, M. LEIMBACH, C. CARRARO, K. HASSELMANN, J.C. HOURCADE, A. KEELER and R. KLEIN* (liii): Integrated Assessment Modeling: Modules for Cooperation
CLIM	54.2002	*Scott BARRETT* (liii)*:* Towards a Better Climate Treaty
ETA	55.2002	*Richard G. NEWELL and Robert N. STAVINS*: Cost Heterogeneity and the Potential Savings from Market-Based Policies
SUST	56.2002	*Paolo ROSATO and Edi DEFRANCESCO*: Individual Travel Cost Method and Flow Fixed Costs
SUST	57.2002	*Vladimir KOTOV and Elena NIKITINA* (lvii): Reorganisation of Environmental Policy in Russia: The Decade of Success and Failures in Implementation of Perspective Quests
SUST	58.2002	*Vladimir KOTOV* (lvii): Policy in Transition: New Framework for Russia's Climate Policy
SUST	59.2002	*Fanny MISSFELDT and Arturo VILLAVICENCO* (lvii): How Can Economies in Transition Pursue Emissions Trading or Joint Implementation?
VOL	60.2002	*Giovanni DI BARTOLOMEO, Jacob ENGWERDA, Joseph PLASMANS and Bas VAN AARLE:* Staying Together or Breaking Apart: Policy-Makers' Endogenous Coalitions Formation in the European Economic and Monetary Union
ETA	61.2002	*Robert N. STAVINS, Alexander F.WAGNER and Gernot WAGNER*: Interpreting Sustainability in Economic Terms: Dynamic Efficiency Plus Intergenerational Equity
PRIV	62.2002	*Carlo CAPUANO*: Demand Growth, Entry and Collusion Sustainability
PRIV	63.2002	*Federico MUNARI and Raffaele ORIANI*: Privatization and R&D Performance: An Empirical Analysis Based on Tobin's Q
PRIV	64.2002	*Federico MUNARI and Maurizio SOBRERO*: The Effects of Privatization on R&D Investments and Patent Productivity
SUST	65.2002	*Orley ASHENFELTER and Michael GREENSTONE*: Using Mandated Speed Limits to Measure the Value of a Statistical Life
ETA	66.2002	*Paolo SURICO:* US Monetary Policy Rules: the Case for Asymmetric Preferences
PRIV	67.2002	*Rinaldo BRAU and Massimo FLORIO*: Privatisations as Price Reforms: Evaluating Consumers' Welfare Changes in the U.K.
CLIM	68.2002	*Barbara K. BUCHNER and Roberto ROSON*: Conflicting Perspectives in Trade and Environmental Negotiations
CLIM	69.2002	*Philippe QUIRION*: Complying with the Kyoto Protocol under Uncertainty: Taxes or Tradable Permits?
SUST	70.2002	*Anna ALBERINI, Patrizia RIGANTI and Alberto LONGO*: Can People Value the Aesthetic and Use Services of Urban Sites? Evidence from a Survey of Belfast Residents
SUST	71.2002	*Marco PERCOCO:* Discounting Environmental Effects in Project Appraisal

NRM	72.2002	*Philippe BONTEMS and Pascal FAVARD*: Input Use and Capacity Constraint under Uncertainty: The Case of Irrigation
PRIV	73.2002	*Mohammed OMRAN:* The Performance of State-Owned Enterprises and Newly Privatized Firms: Empirical Evidence from Egypt
PRIV	74.2002	*Mike BURKART, Fausto PANUNZI and Andrei SHLEIFER:* Family Firms
PRIV	75.2002	*Emmanuelle AURIOL, Pierre M. PICARD:* Privatizations in Developing Countries and the Government Budget Constraint
PRIV	76.2002	*Nichole M. CASTATER***:** Privatization as a Means to Societal Transformation: An Empirical Study of Privatization in Central and Eastern Europe and the Former Soviet Union
PRIV	77.2002	*Christoph LÜLSFESMANN*: Benevolent Government, Managerial Incentives, and the Virtues of Privatization
PRIV	78.2002	*Kate BISHOP, Igor FILATOTCHEV and Tomasz MICKIEWICZ*: Endogenous Ownership Structure: Factors Affecting the Post-Privatisation Equity in Largest Hungarian Firms
PRIV	79.2002	*Theodora WELCH and Rick MOLZ*: How Does Trade Sale Privatization Work? Evidence from the Fixed-Line Telecommunications Sector in Developing Economies
PRIV	80.2002	*Alberto R. PETRUCCI*: Government Debt, Agent Heterogeneity and Wealth Displacement in a Small Open Economy
CLIM	81.2002	*Timothy SWANSON and Robin MASON* (lvi): The Impact of International Environmental Agreements: The Case of the Montreal Protocol
PRIV	82.2002	*George R.G. CLARKE and Lixin Colin XU:* Privatization, Competition and Corruption: How Characteristics of Bribe Takers and Payers Affect Bribe Payments to Utilities
PRIV	83.2002	*Massimo FLORIO and Katiuscia MANZONI*: The Abnormal Returns of UK Privatisations: From Underpricing to Outperformance
NRM	84.2002	*Nelson LOURENÇO, Carlos RUSSO MACHADO, Maria do ROSÁRIO JORGE and Luís RODRIGUES*: An Integrated Approach to Understand Territory Dynamics. The Coastal Alentejo (Portugal)
CLIM	85.2002	*Peter ZAPFEL and Matti VAINIO* (lv): Pathways to European Greenhouse Gas Emissions Trading History and Misconceptions
CLIM	86.2002	*Pierre COURTOIS*: Influence Processes in Climate Change Negotiations: Modelling the Rounds
ETA	87.2002	*Vito FRAGNELLI and Maria Erminia MARINA* (lviii): Environmental Pollution Risk and Insurance
ETA	88.2002	*Laurent FRANCKX* (lviii): Environmental Enforcement with Endogenous Ambient Monitoring
ETA	89.2002	*Timo GOESCHL and Timothy M. SWANSON* (lviii): Lost Horizons. The noncooperative management of an evolutionary biological system.
ETA	90.2002	*Hans KEIDING* (lviii): Environmental Effects of Consumption: An Approach Using DEA and Cost Sharing
ETA	91.2002	*Wietze LISE* (lviii): A Game Model of People's Participation in Forest Management in Northern India
CLIM	92.2002	*Jens HORBACH*: Structural Change and Environmental Kuznets Curves
ETA	93.2002	*Martin P. GROSSKOPF:* Towards a More Appropriate Method for Determining the Optimal Scale of Production Units
VOL	94.2002	*Scott BARRETT and Robert STAVINS*: Increasing Participation and Compliance in International Climate Change Agreements
CLIM	95.2002	*Banu BAYRAMOGLU LISE and Wietze LISE:* Climate Change, Environmental NGOs and Public Awareness in the Netherlands: Perceptions and Reality
CLIM	96.2002	*Matthieu GLACHANT*: The Political Economy of Emission Tax Design in Environmental Policy
KNOW	97.2002	*Kenn ARIGA and Giorgio BRUNELLO*: Are the More Educated Receiving More Training? Evidence from Thailand
ETA	98.2002	*Gianfranco FORTE and Matteo MANERA*: Forecasting Volatility in European Stock Markets with Non-linear GARCH Models
ETA	99.2002	*Geoffrey HEAL*: Bundling Biodiversity
ETA	100.2002	*Geoffrey HEAL, Brian WALKER, Simon LEVIN, Kenneth ARROW, Partha DASGUPTA, Gretchen DAILY, Paul EHRLICH, Karl-Goran MALER, Nils KAUTSKY, Jane LUBCHENCO, Steve SCHNEIDER and David STARRETT*: Genetic Diversity and Interdependent Crop Choices in Agriculture
ETA	101.2002	*Geoffrey HEAL:* Biodiversity and Globalization
VOL	102.2002	*Andreas LANGE*: Heterogeneous International Agreements – If per capita emission levels matter
ETA	103.2002	*Pierre-André JOUVET and Walid OUESLATI*: Tax Reform and Public Spending Trade-offs in an Endogenous Growth Model with Environmental Externality
ETA	104.2002	*Anna BOTTASSO and Alessandro SEMBENELLI*: Does Ownership Affect Firms' Efficiency? Panel Data Evidence on Italy
PRIV	105.2002	*Bernardo BORTOLOTTI, Frank DE JONG, Giovanna NICODANO and Ibolya SCHINDELE*: Privatization and Stock Market Liquidity
ETA	106.2002	*Haruo IMAI and Mayumi HORIE* (lviii): Pre-Negotiation for an International Emission Reduction Game
PRIV	107.2002	*Sudeshna GHOSH BANERJEE and Michael C. MUNGER*: Move to Markets? An Empirical Analysis of Privatisation in Developing Countries
PRIV	108.2002	*Guillaume GIRMENS and Michel GUILLARD*: Privatization and Investment: Crowding-Out Effect vs Financial Diversification
PRIV	109.2002	*Alberto CHONG and Florencio LÓPEZ-DE-SILANES*: Privatization and Labor Force Restructuring Around the World
PRIV	110.2002	*Nandini GUPTA*: Partial Privatization and Firm Performance
PRIV	111.2002	*François DEGEORGE, Dirk JENTER, Alberto MOEL and Peter TUFANO*: Selling Company Shares to Reluctant Employees: France Telecom's Experience

PRIV	112.2002	*Isaac OTCHERE*: Intra-Industry Effects of Privatization Announcements: Evidence from Developed and Developing Countries
PRIV	113.2002	*Yannis KATSOULAKOS and Elissavet LIKOYANNI*: Fiscal and Other Macroeconomic Effects of Privatization
PRIV	114.2002	*Guillaume GIRMENS:* Privatization, International Asset Trade and Financial Markets
PRIV	115.2002	*D. Teja FLOTHO:* A Note on Consumption Correlations and European Financial Integration
PRIV	116.2002	*Ibolya SCHINDELE and Enrico C. PEROTTI*: Pricing Initial Public Offerings in Premature Capital Markets: The Case of Hungary
PRIV	1.2003	*Gabriella CHIESA and Giovanna NICODANO*: Privatization and Financial Market Development: Theoretical Issues
PRIV	2.2003	*Ibolya SCHINDELE*: Theory of Privatization in Eastern Europe: Literature Review
PRIV	3.2003	*Wietze LISE, Claudia KEMFERT and Richard S.J. TOL*: Strategic Action in the Liberalised German Electricity Market
CLIM	4.2003	*Laura MARSILIANI and Thomas I. RENSTRÖM*: Environmental Policy and Capital Movements: The Role of Government Commitment
KNOW	5.2003	*Reyer GERLAGH*: Induced Technological Change under Technological Competition
ETA	6.2003	*Efrem CASTELNUOVO*: Squeezing the Interest Rate Smoothing Weight with a Hybrid Expectations Model
SIEV	7.2003	*Anna ALBERINI, Alberto LONGO, Stefania TONIN, Francesco TROMBETTA and Margherita TURVANI:* The Role of Liability, Regulation and Economic Incentives in Brownfield Remediation and Redevelopment: Evidence from Surveys of Developers
NRM	8.2003	*Elissaios PAPYRAKIS and Reyer GERLAGH*: Natural Resources: A Blessing or a Curse?
CLIM	9.2003	*A. CAPARRÓS, J.-C. PEREAU and T. TAZDAÏT*: North-South Climate Change Negotiations: a Sequential Game with Asymmetric Information

(l) This paper was presented at the Workshop "Growth, Environmental Policies and Sustainability" organised by the Fondazione Eni Enrico Mattei, Venice, June 1, 2001

(li) This paper was presented at the Fourth Toulouse Conference on Environment and Resource Economics on "Property Rights, Institutions and Management of Environmental and Natural Resources", organised by Fondazione Eni Enrico Mattei, IDEI and INRA and sponsored by MATE, Toulouse, May 3-4, 2001

(lii) This paper was presented at the International Conference on "Economic Valuation of Environmental Goods", organised by Fondazione Eni Enrico Mattei in cooperation with CORILA, Venice, May 11, 2001

(liii) This paper was circulated at the International Conference on "Climate Policy – Do We Need a New Approach?", jointly organised by Fondazione Eni Enrico Mattei, Stanford University and Venice International University, Isola di San Servolo, Venice, September 6-8, 2001

(liv) This paper was presented at the Seventh Meeting of the Coalition Theory Network organised by the Fondazione Eni Enrico Mattei and the CORE, Université Catholique de Louvain, Venice, Italy, January 11-12, 2002

(lv) This paper was presented at the First Workshop of the Concerted Action on Tradable Emission Permits (CATEP) organised by the Fondazione Eni Enrico Mattei, Venice, Italy, December 3-4, 2001

(lvi) This paper was presented at the ESF EURESCO Conference on Environmental Policy in a Global Economy "The International Dimension of Environmental Policy", organised with the collaboration of the Fondazione Eni Enrico Mattei , Acquafredda di Maratea, October 6-11, 2001

(lvii) This paper was presented at the First Workshop of "CFEWE – Carbon Flows between Eastern and Western Europe", organised by the Fondazione Eni Enrico Mattei and Zentrum fur Europaische Integrationsforschung (ZEI), Milan, July 5-6, 2001

(lviii) This paper was presented at the Workshop on "Game Practice and the Environment", jointly organised by Università del Piemonte Orientale and Fondazione Eni Enrico Mattei, Alessandria, April 12-13, 2002

2002 SERIES

CLIM *Climate Change Modelling and Policy* (Editor: Marzio Galeotti)

VOL *Voluntary and International Agreements* (Editor: Carlo Carraro)

SUST *Sustainability Indicators and Environmental Valuation* (Editor: Carlo Carraro)

NRM *Natural Resources Management* (Editor: Carlo Giupponi)

KNOW *Knowledge, Technology, Human Capital* (Editor: Dino Pinelli)

MGMT *Corporate Sustainable Management* (Editor: Andrea Marsanich)

PRIV *Privatisation, Regulation, Antitrust* (Editor: Bernardo Bortolotti)

ETA *Economic Theory and Applications* (Editor: Carlo Carraro)

2003 SERIES

CLIM *Climate Change Modelling and Policy* (Editor: Marzio Galeotti)

GG *Global Governance* (Editor: Carlo Carraro)

SIEV *Sustainability Indicators and Environmental Valuation* (Editor: Anna Alberini)

NRM *Natural Resources Management* (Editor: Carlo Giupponi)

KNOW *Knowledge, Technology, Human Capital* (Editor: Gianmarco Ottaviano)

IEM *International Energy Markets* (Editor: Anil Markandya)

CSRM *Corporate Social Responsibility and Management* (Editor: Sabina Ratti)

PRIV *Privatisation, Regulation, Antitrust* (Editor: Bernardo Bortolotti)

ETA *Economic Theory and Applications* (Editor: Carlo Carraro)