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Influence Processes in Climate Change Negotiations: Modelling the Rounds

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Keywords: Imitation, persuasion, climate change negotiation, master equation

JEL: D74, Q28

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Abstract

I present in this paper an integrated framework for structuring and evaluating dynamic and sequential climate change decision making in the international arena taking into account influence processes occuring during negotiation rounds. The analysis integrates imitation, persuasion and dissuasion behaviors. The main innovation brought in the approach is the presentation of a stochastic model framework derived from thermodynamics. The so-called master equation is introduced in order to better understand strategic switch and influence games exerted. The model is illustrated toward a simulation of climate change conferences decision making processes. Characteristics of regions behaviors are derived from the simulations. In particular the bargain behaviors allowing for the emergence of an agreement are presented.

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1 Introduction

Climate change threats have spawned numerous researches on improved methods to enlighten policymakers on main issues related to emission control options and strategic analysis of the negotiation process. A range of *integrated assessment* models emerged to pull together most of the features of the problem into a consistent framework and game theoretic analyses were proposed to capture the

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dynamics of decision making in a universe grasping interactions. Applications gathering both integrated assessment results and game theoretic frameworks were then proposed. Peck and Teisberg (1995) used a two regions disaggregation of the CETA model to explore game theoretic outcomes of a number of climate policies. Botteon and Carraro (1997;1998) used the six regions disaggregation of the RICE 1996 model to study best response and Shapley value to discuss the most appropriate sharing rule to optimize cooperation. Germain et al (1998) or Eycmans and Tulkens (1999) used the RICE 1996 model to study the transfer rule allowing full cooperation. Lately, researches focused increasingly on refined approaches of the negotiation process representation. Dynamic analyses were thus presented by Peck and Teisberg (1999) or Babiker et al (2000) and sequential decision making frameworks were proposed in an attempt to capture the proceeding of negotiation process (Ciscar and Soria (2000), Toth et al (2001)). Likewise, other equilibrium concepts and methods were introduced to provide integrated tools aiming at always better picture decision making and related issues.

In this last perspective, we present a modelling framework to simulate international negotiation participation taking into account influence behaviors which occur during the negotiation process itself. More accurately, we propose on the basis of the Toth et al (2001) model simulation to develop a modelling module inspired from stochastic game dynamical equations. Recall indeed that in non cooperative game theoretic studies, it is commonly and implicitly envisioned that countries negotiate but never meet. It is thus supposed that countries interact but do not influence each other. In other words, talks and discussions within negotiation protocols would have strictly no influence on negotiation outcomes. Then one can ask why we should call these approaches negotiation studies since they omit the negotiation process by itself. This statement is all the more striking that past international negotiation experiences seem to confirm that countries influence each other during the negotiation process via the exerts of instrumental, structural and by example leaderships (Gupta and Grubb (2000); Courtois (2001)). For example, the long range transboundary pollution protocol signed in Helsinki (1985) was significantly the result of persuasions exerted by Germany which on top gave the example to follow (Boemer and Christiansen (1991)). Likewise, the ozone layer protocol signed in Montreal (1988) is usually interpreted as the result of both United States exerts of coercition and Mostapha Tolba mediation role (Oberthuer 2000). Back to climate change negotiation, Bonn and Marakech conferences last year were characterized by long run talks. The final agreement signed in Marakech in July demonstrated to be the result of compromise and long standing conciliatory efforts made by the President of the Conference of the Parties (CoP) as well as of several delegation chiefs (Jacoby and Reiner 2001). It calls thus for a more comprehensive analysis of what Schelling (1960) defines as explicite negotiation. Imitative, persuasive and dissuasive behaviors characterizing negotiation outcomes need to be taken into account. Some of these behaviors were already mentioned in game theoretic literature related to climate change negotiation. In particular, Carraro (2000) assimilated persuasion to pecuniary or technological transfers and dissuasion to pecuniary sanction. Explicite negotiation refers nevertheless to influence behaviors rather than positive and negative incentives which represent only specific means to exert influences. First, other means are made available. Above all, issue linkages are the principal source of persuasion/dissuasion as international negotiation are made of overlaping diplomatic relations. Second, beside means to exert influences, there are degrees characterizing countries' incline to get influenced by other. For instance, a country can be uncertain on the strategy to follow. One can assume then that he would have strong tendency to get influenced by a leader and to follow examples through mimic behaviors. On the other hand a country can demonstrate to be stubborn and follow a strategy defined outside the negotiation arena. The rational of countries' decision making is hence the cornerstone of the discussion.

Rationality in game theory refers basically to optimization behavior as well as to common knowledge. It is commonly accepted in the literature that cost and damage related to climate change are highly uncertain and controversial. Informations and beliefs necessary to perform optimization procedure are therefore partly issued from negotiation talks and from other countries' behavior. At an extreme we can refer here to autoreferential mimetism as defined by Orlean (1989). Common knowledge is also questionable and we rather should refer to common belief as suggered by Brandenburger and Dekel (1987). Explicite negotiation in our case study is the source from which actors derive these believes. It follows a framework characterized by actors playing within a universe of limited rationality.

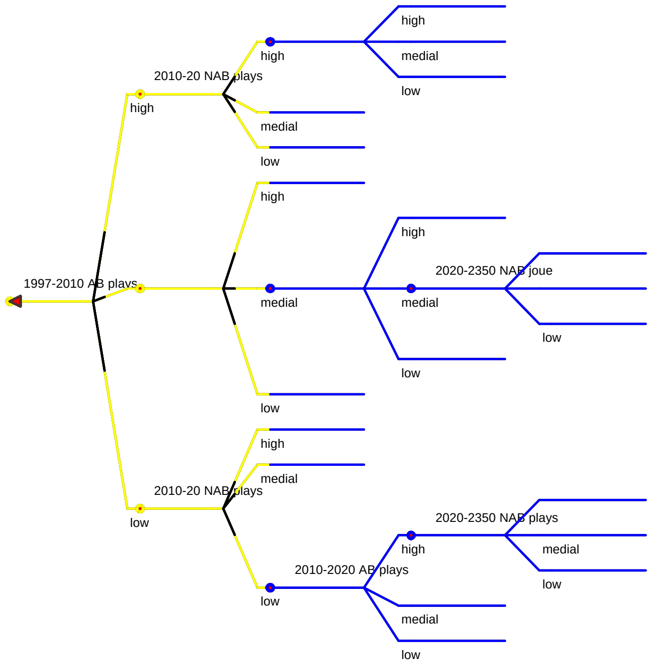
Economic theory and more precisely game theory is not powerless within a universe of limited rationality. Uncertainty can be as well implemented into this kind of analysis. The method followed here finds however more analogy with stochastic evolutionary game theory than with orthodox game theory. The modelling framework presented is indeed inspired from concept of synergetics originally developed in elementary particle and laser physics (Haken 1983) and applied to various problems from the social sciences by Weildlich and Haag (1983), Topol (1991) or Lux (1995). This conceptual choice allows to consider players who do not have access to enough information to follow an optimization procedure and who are inclined to be influenced by other players.

The remainder of the paper is organised as follows. Section 2 outlines the theoretical foundation used and focuses on the basic set up of the model toward a description of the negotiation process described. Section 3 defines the model developed to represent influences within each negotiation rounds considered. Analogy to evolutionary game theory is briefly described. Section 4 explains influence valuation. Influence considered as well as valuation method are described. Thereafter, a simulation is proposed in section 5. The method to bridge the dynamic and sequential model from Toth et al (2001) and the influence model is explained. Desutility and influence rate valuation methods are presented and a brief discussion is opened on countries behaviors within negotiation arenas. Finally, we conclude the findings of the paper in section 6.

2 Representing Influences : Basic Set up of the Negotiation Process

One of the most up to date model gathering *integrated assessment modelling* and game theory analysis is the dynamic and sequential model from Toth et al (2001). Based on the RICE 1999 multiregional model from Nordhaus and Boyer, Toth et al developed the SIADCERO family models to describe potential outcomes of the climate change negotiation. The approach followed is innovative since it takes into account the sequentiality of decision making. Recall that two information structures are available for modelling games, the open loop and close loop frameworks. While in open loop games, players do not observe past moves of other participants, in close loop games all past strategies of other players are known at the beginning of each stage. In this last configuration, players react to past moves of other participants and can change strategy from one stage to another. Usual modelling approaches use the first configuration. This is due to the nature of *integrated assessment modelling* which proceeds to an intertemporal optimization of an objective function subject to a set of restrictions. The objective function is usually the discounted utility of the present value of per capita consumption or production times the population. It results from these models, estimations of controle variables (e.g. investment rate, labor rate, emission rate) allowing to stay on an optimal economic path over a given time period (usually rather long). The main drawback it involves while modelling negotiation games is that countries are thus inevitably deciding now on the strategy they will follow over the time period considered by the *integrated assessment model* (generally from 100 to 300 years). It follows that countries cannot change their mind, respond to free riding behavior from other players and so on. This is the reason for Toth et al propose instead to use the second configuration. For that matter, the integrated assessment model they develop optimizes over a set of discrete time periods. Furthermore, emission rates are exogeneous and thus are associated to discrete strategies.

The negotiation picture corresponding to their model is made of a succession of three negotiation periods in which the regions considered (from 2 to 5 according to the version of the model) have the choice in between three strategies. The backward induction procedure allow to determine the outcome of the game.



Extensive form of the 2 region model

The three periods are the Kyoto period (from now to 2010), the post Kyoto period (from 2010 to 2020) and the long term period (from 2020 to 2350).[1] The three strategies are the low, medial and high emission reduction rates corresponding respectively to the defection, the half completion and the completion of the Kyoto targets. Finally, both best response and correlated equilibria concepts are studied. It results from the approach a nice description of the possible outcomes of the climate change negotiation. A political analysis is made possible and in particular the model allows to study the most appropriate configuration to reach full cooperation at the post kyoto period.

It remains that despite the fact that sequentiality is taken into account, the bargaining issue within negotiation rounds itselfs are absent from this approach. In line with the methodology followed by Lux (1995) to model mimetic bubles and financial crashes, we propose to introduce a simple formalism which can be overlayed to the standard game theoretic representation. In this perspective, the present model should not be seen as antagonistic to the recent literatture modelling negotiation process but complementary.

Precisely, we propose to develop a stochastic module to be added to the Toth et al model in order to represent influence behaviors occuring during negotiation rounds. The underlying idea is that each country's head of delegation knows *a priori* what would be his strategy if it was no international CoP. This strategy can indeed be deduced from a model of the kind of Toth et al (2001). In

[1]Note that this last period does not make much sense given the horizon time. In the following we will thus consider only the two first periods.

other words, we consider that at the beginning of each negotiation CoP, heads of delegation know the best response outcomes of the game. Players know nevertheless that the information at their disposal is imperfect. In particular they don't know exactly the benefits from reducing emissions. Their knowledge on avoided climatic impacts is bounded as well as the diplomatic price of defection. One can assume thus that their belief into their best response function is rather limited. The CoP could hence be thought as a place where these players get informations to decide eventually which strategy to follow. Moreover, knowing that other national delegations have doubts on their move, one can assume that countries expect to influence other players to choose a move serving their own interest. In other words during the negotiation rounds, we consider here that players attempt to influence others and can as well be influenced.

More accurately, four influences can be taken into account : imitation, persuasion, dissuasion and avoidance. These behaviors can be regouped into two kinds of behaviors. The first kind is the tendency for an environmentalist country to push other delegations to accept high emission reduction rate. Via oral prestations, a head of delegation can indeed persuade other players to adopt a specific policy. He can call for another country to follow his example or as well dissuade another delegation to play a given strategy. Unfortunately on the other hand, this environmentalist country can have a tendency to defect if he is confronted to a majority of environmental lagards via persuasion, dissuasion or imitation. The second kind of behavior characterizes negotiation bargain, this is avoidance processes. A delegation becoming aware of a large amount of players adopting ambitious strategy (respectively adopting a defection strategy) can decide to defect (respectively to adopt an ambitious strategy). In the presence of a large movement of defection, a country can indeed decide to adopt an ambitious strategy conceived here as a precautionary behavior. Likewise in case many players adopt a stringent environmental policy, a country can decide to adopt a defection strategy conceived here as a free rider behavior.

The strategy switch occuring during the bargaining process is thus explained by interactions in between players. During the negotiation, delegations negotiate, pick information and exchange points of view. In analogy with Lewin (1951), we consider therefore that player behavior is also defined by a *social field*. The more players interact during the CoP the more the influence process is significant. Furthermore, strategy switch is all the more frequent because the differential payoff between the strategy initially picked up and the strategy suggested during the negotiation process is low. We consider therefore that players will have a tendency to be influenced all the more because they expect to not be able to loose significantly from following the suggested strategy (in fact, players expect to get higher payoff following the suggestion - they cannot nevertheless evaluate this expected gain given uncertainties surrounding the issue).

Influence of talks and oral pressures are difficult to estimate. At that respect the model developed here is a simplification of the reality. We propose to present a modelling framework but influence rates used are fixed in an *ex nihilo* manner. The framework in itself constitutes nevertheless a major step in negotiation analysis since it allows to consider the influence of the negotiation process. To model influences inherent to the *social field*, the approach followed is inspired from the stochastic physic model from Boltzmann (1964). In other words the most likely behavioral switch is dicted by a matrix or a vector quantity which in analogy to Boltzmann study can be interpreted as a *social force*.[2]

3 The Model

Consider a system, a global environmental negotiation, constituted by an important amount of subsystems N, denoting the countries/actors participating in this negotiation. Let assemble these subsystems in a set of A populations a, denoting categories of countries characterized by relatively similar utility in negotiation outcomes, made of N_a actors.[3]

$$\sum_{a=1}^{A} N_a = N \tag{1}$$

Each population is distributed according to different states x, denoting actors strategies, among s possible states. Using this nomenclature, n_x^a denote the amount of actors of population a adopting strategy x.

It follows:

$$\sum_{x=1}^{s} n_x^a = N_a \tag{2}$$

with the vector:

$$v = (n_1^1, ..., n_x^a, ..., n_s^A)$$

representing the configuration of the system. This vector captures the information set associated to the distribution of the N subsystems over the s possible states.

Let $P(v,t)$ denotes the probability of having a configuration v at time t.

It follows:

$$0 \leq P(v,t) \leq 1 \text{ and } \sum_{v=1}^{A*s} P(v,t) = 1$$

[2]Note that to use a stochastic framework is plenty justifiable here since up to1500 negotiators participate to each CoP.

[3]Note that assembling countries in categories allow us to consider a certain level of heterogeneity in between players.

Variations over time of probability $P(v,t)$ can be represented by the master equation:

$$\frac{d}{dt}P(v,t) = \text{convergence flow toward } v \text{ - divergence flow from } v$$
$$\sum_{v'(v \neq v')} W(v \backslash v';t)P(v',t) - \sum_{v'(v \neq v')} W(v' \backslash v;t)P(v,t) \quad (3)$$

The convergence flow toward v corresponds to the sum of all absolute transitions describing a behavior switch from configuration v' to configuration v. Respectively, the divergence flow from v corresponds to the sum of all absolute transitions describing a behavior switch from configuration v to configuration v'. $W(v' \backslash v;t)$ is the transition rate from configuration v to configuration v'. We consider that an actor switch behavioral strategy spontaneously or because of an interaction with another actor. Spontaneous behavioral change is explained by a utility improvement of one strategy upon another. This utility improvement is due to a peculiar event or to the diffusion of a specific information which modify relative strategies' utility. For instance, the discovery of forest death, the so called waldsterben, modified countries' behavioral strategy radically within transboundary air pollution negotiation in 1983. Likewise, the evidence of the ozone hole constituted a turning point of the ozone layer negotiation in 1987. Alternatively, strategy switch from interaction results from economic or politic interdependancies in between actors. For instance, one can quote the political pressure as well as the imitation of the turnkey political solution provided by Germany within the long range transboundary negotiation. Remind indeed that most of European states adopted the 1986 LCP european directive which was a waterdown policy based on the GFAV directive adopted by Germany in 1984.

Transition rate can be decomposed as follow:

$$W(v' \backslash v) = \left\{ \begin{array}{c} W_1(x' \backslash x;t)n_x^a \text{ if } v' = v_{x'x} \\ W_2(x',y' \backslash x,y;t)n_x^a n_x^b \text{ if } v' = v_{x'y'xy} \\ 0 \text{ else} \end{array} \right\}$$

With W_1, the spontaneous transition rate and W_2 the interaction transition rate.

For example, an actor from a which followed a $x-$strategy can switch spontaneously to a $x'-$strategy independantly from other actors constituting the system. Then the socioconfiguration becomes:

$$v_{x'x'}^a = (n_1^1, ..., (n_{x'}^a + 1), ..., (n_x^a - 1), ..., n_s^A)$$

Likewise an actor from a following initially a $x-$strategy can switch to an $x'-$strategy subsequently to an interaction with an actor from b following initially a $y-$strategy who will switch to a $y'-$strategy. The transition rate in this particular case is $W_2(x\prime, y\prime \backslash x, y; t)$.

The corresponding configuration change is:

$$v^{ab}_{x'y'xy} = (n^1_1, ..., (n^a_{x'} + 1), ..., (n^a_x - 1), ..., (n^b_{y'} + 1), ..., (n^b_y - 1), ..., n^A_s)$$

We have consequently:

$$\begin{aligned}\frac{d}{dt}P(v,t) &= \sum_{a,x,x'} [(n^a_{x'}+1)W_1(x,x';t)P(n^a_{x'x},t) - n^a_x W_1(x',x;t)P(n,t)] + \\ & \frac{1}{2}\sum_{a,x,x'}\sum_{b,y,y'} [(n^a_{x'}+1)(n^b_{y'}+1)W_2(x,y,x',y';t)P(n^{ab}_{x'y'xy},t) \\ & -n^a_x n^b_y W_2(x',y',x,y;t)P(n,t)]\end{aligned}$$

4 Influences Valuation

The aim of the model is to estimate evolutions of vector v. It is therefore necessary to estimate strategic switches from actors constituting the system. To achieve so, formal categories of influences and a corresponding valuation procedure need to be defined.

4.1 Category of Influences

Given three environemental strategies x_a, x_m, x_d, with x_a an ambitious strategy, x_m.a medial strategy and x_d a defection strategy.

Let k denotes the kind of influence exerted, $k = \{1, 2\}$ with:

- $k = 1$ describing imitative processes: the tendency to adopt the strategy of another actor.
- $k = 2$ describing avoiding processes: The tendency to switch strategy as a result of interacting with an actor following the same strategy.

Lets note:
$x_m, x_d \longrightarrow x_d, x_d$

> the interaction between an actor playing initially strategy x_m and an actor playing strategy x_d, leading to a strategic change characterized by the adoption of strategy x_d by the first actor and the keeping of the same strategy for the other.

The set of strategic switch as a result of actors' interactions can be classified in the following manner:

$$\begin{bmatrix} x_m, x_d \longrightarrow x_m, x_m \\ x_m, x_d \longrightarrow x_d, x_d \\ x_m, x_a \longrightarrow x_m, x_m \\ x_m, x_a \longrightarrow x_a, x_a \\ x_a, x_d \longrightarrow x_d, x_d \\ x_a, x_d \longrightarrow x_a, x_a \end{bmatrix} (k=1) \qquad \begin{bmatrix} x_m, x_m \longrightarrow x_m, x_a \\ x_m, x_m \longrightarrow x_m, x_d \\ x_d, x_d \longrightarrow x_m, x_d \\ x_d, x_d \longrightarrow x_a, x_d \\ x_a, x_a \longrightarrow x_m, x_a \\ x_a, x_a \longrightarrow x_d, x_a \end{bmatrix} (k=2)$$

Note that other influence categories could be specified. They are nevertheless excluded since they correspond to behavioral change which are inapropriate within global environmental negotiations. As an example, we exclude the case of two actors playing initially strategy x_a which, as a result of the interaction would both play x_d. It would mean indeed that the negotiation process favors the transition from understandings to global defection which would make no sense.

4.2 Dynamic Valuation : a Model for the Simulation

Given n regions α, with $1 \leq \alpha \leq n$. Each region has the choice between s strategies x_i, with $1 \leq i \leq s$. Variation of the amount of actors playing strategy x_i is:

$$\begin{aligned} \frac{d}{dt}P(x_i,t) &= \text{convergence flow toward } x_i \text{ - divergence flow from } x_i \\ & \sum_{x_j}[W(x_i\backslash x_j;t)P(x_j,t) - W(x_j\backslash x_i;t)P(x_i,t)] \end{aligned} \tag{4}$$

With $W(x_i\backslash x_j;t)$, the transition rate due to interactions. At this rate corresponds the following relation:

$$W(x_i\backslash x_j;t) = \sum_{k=1}^{2} w^k(x_i\backslash x_j;t) \tag{5}$$

Denote $I_\alpha^k(t)$ the influence rate of type k corresponding to interactions between region α and other regions at period t. $R_\alpha(x_i\backslash x_j;t)$ is the relative utility for region α to switch from strategy x_j to strategy x_i, all other things being equal.

It follows:

$$\sum_{k=1}^{2} w^k(x_i\backslash x_j;t) = \sum_{\alpha=1}^{n-1}\sum_{j=1,j\neq i}^{s-1} R_\alpha(x_i\backslash x_j;t)[I_\alpha^1(t)P^\Theta(x_i,t) + I_\alpha^2(t)P^\Theta(x_j,t)] \tag{6}$$

With $P^{\Theta}(x_i, t)$, the proportion of other regions playing x_i at period t. Likewise $P(x_i, t)$ is the total proportion of regions playing strategy x_i at time t. Once $R(x_i \backslash x_j; t)$ are defined and influence rates specified, transition dynamics of regions strategic behavior and total variations of $P(x_i, t)$ can be described. Overall strategic changes allows to deduce the variation of the system at period t and hence to derive a dynamic picture of decision making.

5 Simulation of Negotiation Dynamics

Let consider three regional blocs : the European Union + the Former Soviet Union (EU+FSU), the UMBRELLA region (UMB) and the Rest of the World (RoW). Each of these blocs is considered to dispose of a valuation of its best response strategy at the beginning of each CoP.[4] The goal of participating to CoP is to negotiate together multilateral strategies. Indeed, despite the fact that the model suggesting Nash strategies assume that players are rational and have perfect informations, heads of delegations are conscious that information is unperfect and they know that the bargaining process will have an influence on players' strategies. In other words, they consider the modelling tools as simplified representations serving at enlightening decision making rather than giving solutions.

At CoP, talks are based initially on the information each region dispose that is their Nash strategy valuation. If we consider that each CoP is two weeks long, we can assume that $t = 35$. It means that players interact approximately twice a day. We make the assumption as well that influence rates are static meaning that tendencies to be influenced are similar from the beginning to the end of the CoP.

To propose a simulation of negotiation dynamics we propose in the next subsections to evaluate first relative utilities $R(x_i \backslash x_j; t)$ and second to postulate assumptions regarding influence rates I.

5.1 Desutility Valuation

The dynamic and sequential model from Toth et al (2001) allows to derive discounted utilities associated to each strategic choice for the two negotiation periods considered (the Kyoto and post Kyoto periods). We know consequently the utility corresponding to the Nash outcome for a given player. The integrated model allows us as well to evaluate utilities associated to other set of strategies.

$R(x_i \backslash x_j; t)$ corresponds to the distance in between payoffs related to strategy x_i and x_j. This distance is the relative desutility to play x_i rather than x_j. In terms of influences it means that the less this distance is significant the more players have tendencies to be influenced and thus to switch strategy.

Payoffs matrixes derive from the Toth et al model 3A are the following, note that bold numbers are utilities corresponding to Nash outcomes.

[4] This valuation is made available thanks to a dynamic and sequential model such as the Toth et al model.

Période de Kyoto 3A

stratégies\régions	UMB	EU+FSU	RDM
ambitieuse	351,590	**253,566**	★
médiane	352,493	253,565	★
défection	**352,721**	252,887	**284,573**

Période post Kyoto 3A

stratégies\régions	UMB	EU+FSU	RDM
ambitieuse	350,722	252,534	284,084
médiane	351,449	252,823	283,719
défection	**352,721**	**253,566**	**284,573**

Relative desutility from playing one strategy upon another can be deduced from these tables. Note that according to the Toth et al model, utility gaps in between strategies are very low. This result is rather striking since it means that whatever the strategy followed, the related payoff is approximately the same. In terms of influences, it means that countries have strong tendencies to be influenced during the negotiation process. To switch strategy does not involve indeed a significant economic loss according to the dynamic and sequential model.

5.2 Influence rates settings

To present simulations, we need to set influence rates. To approximate rates we propose a range of assumptions. First, lets assume that the bargaining process favors the domination of one strategy upon the others. In other words $I^1 > I^2$. We consider thus implicitly that the CoP leads either to an important coalition or to a large movement of defection. The underlying idea captured is that a protocol enter into force only if it is ratified by an important amount of countries. Recall that to enter into force the Kyoto Protocol needs to be ratified by at least 55 signatory countries of the FCCC representing at least 55% of the emiters of CO2 within Annex B. As a consequence and by definition an agreement constituted by three countries as suggered first by Carraro and Siniscalco (1993) does not make much sense. Second, we consider that if an agreement emerges, participating countries will all follow the same constraints meaning that coexistance of medial and high strategies is quite unlikely. Third and in continuity with the first assumption, we consider that the avoiding behavior is quite marginal. Recall that two configurations characterize avoiding processes. The first can be assimilated to precautionary behavior, this is tendency for a country to adopt a medial or a high emission reduction strategy when most countries defect. The second is the tendency for a country to free ride when most of other countries adopt an environmental policy. Both behaviors make sense, to consider them significant would however mean that implicit negotiation is a source of disagreement.

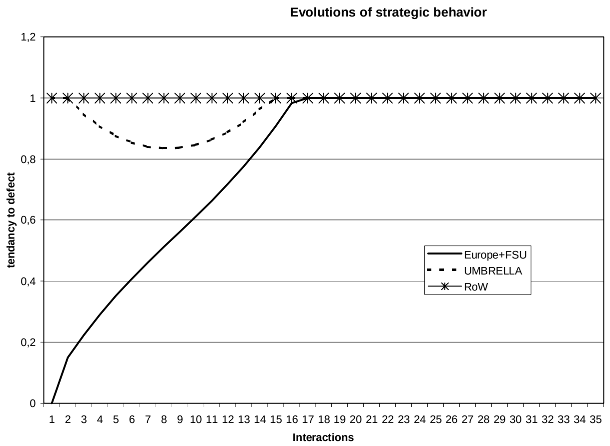
Three simulation scenarios are presented. The first and main one is the *reference scenario*. Annex B countries are characterized by an imitation rate of 25% while the RoW by a rate of 30%. Higher imitation rate by the RoW is justified by the fact that it disposes of limited information and is thus acquainted to recourse to autoreferential mimetism. Avoidance rate is set at 2.5% for Annex B and at 3% for RoW. For all countries, avoidance rate is thus ten times lower than imitation rate. The CoP is as a consequence largely conceived a mean for point of view convergence. Again, we consider that RoW countries have a higher tendency to avoidance behaviors. The explanation is twofold. First, these countries are often lowly developed and have as a consequence other concerns than protecting the environment. It follows that they will be inclined to defect in case Annex B countries adopt ambitious environmental regulations. Second, these countries are as well the main victims from climate change and have an interest to adopt a precautionary behavior in case developed countries defect. The two other scenarios are extreme cases. In the *inflexibility scenario*, imitation and avoidance rates are considered very low. A sensitivity analysis of these rates are proposed in order to determine rate values allowing the emergence of an agreement. In the *influence scenario*, imitation rate is considered high. Likewise, a sensitivity analysis is proposed to determine rate values allowing the emergence of an agreement.

5.3 Results of the Simulation

For both stages of the game, the Kyoto and the post Kyoto CoP, evolutions of strategic behaviors are drawn for each of the three scenarios. The analysis focuses mainly on the first negotiation period. Simulations proved indeed that for the post Kyoto CoP, whatever the influence rates chosen, the outcomes of the game is barely the same. For this period de facto all countries defect. The only way to converge to an agreement would be to have countries characterized by high avoidance rates which does not constitute a realistic alternative.

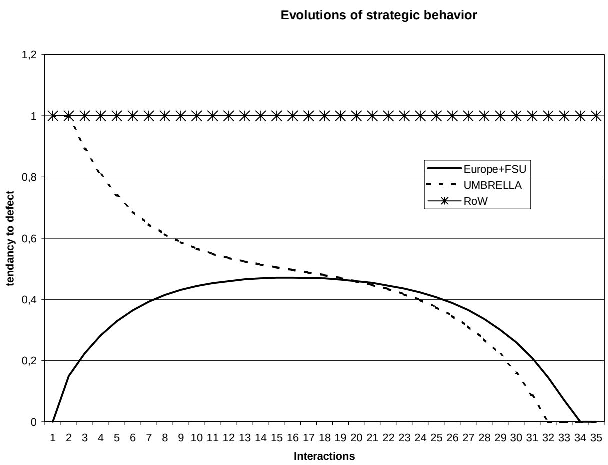
Recall that according to Toth et al simulation, the Nash outcomes is characterized at the Kyoto period (1997-2010) by a defection from the UMBRELLA and the RoW while the EU+FSU plays a high strategy and, at the post Kyoto (2010-2020) by global defection.

Taking into account influence processes occuring during CoPs shows possible evolutions from these outcomes. Considering first the Kyoto period, simulation for the *reference scenario* shows a strategic switch from the EU+FSU. In the figure below, one can notice that at the 15th interaction what is to say after one week of negotiation, all countries agree to not sign any agreement. We consider in the simulation that RoW countries cannot be influenced since non Annex B countries are not suppose to fullfil emission reduction at the first period. They nevertheless participate at the CoP and can influence other players. According to this scenario, the UMBRELLA remains on its defection position. The EU+FSU does not manage to influence other players and switch position to arrive at a situation characterized by global defection.



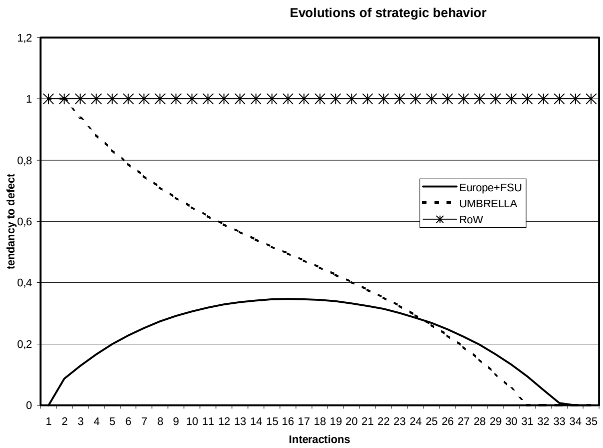
Kyoto, reference scenario

A sensitive analysis allows us to determine that if the UMBRELLA is relatively easily influenced (imitation rate of over 49%) while the EU+FSU keeps the same characteristics than in the reference scenario, the outcome of the game can converge the other way around. In other words, the influence process can favor a situation characterized by the ratification of the Kyoto protocol by all members of the Annex B. For that purpose it is however necessary for the UMBRELLA bloc to be relatively fragmented on its defection position. With an imitation rate of 49% for the UMBRELLA, we can notice in the figure below that approximately at the end of the first week of the CoP, the whole Annex B tends to defend the cooperative outcome.



Kyoto, influence scenario

Another configuration allows full cooperation of the Annex B at the first period. This is the inflexibility outcome. We show that if the EU+FSU is relatively inflexible in fullfiling the Kyoto protocol while other countries keep on the same characteristics than in the reference scenario, the influence process occuring during the bargain tends to force upon the overall ratification of the protocol. This corresponds to an imitation rate of less than 13% in the EU+FSU. The figure below simulates the strategic behavior switch of the UMBRELLA involved by an imitation rate of 13% in the EU+FSU, the avoidance rate being of 1%.



Kyoto, inflexibility scenario

Regarding the second period, we demonstrate in the simulation exercise that if $I^1 > I^2$ there is no means to insure cooperation after 2010. In case regions are characterized by an avoidance rate higher than the imitation rate, we can show that one region will tend to adopt a precautionary behavior. It remains that no global agreement is feasible whatever is the configuration considered. Given the characteristic of the climate change impact repartition, one can forecast that the RoW could adopt such precautionary behavior in 2010, all members of Annex B defecting beside.

6 Conclusion

On July 25 2001, the Bonn agreement was formally adopted at CoP6bis. At the closure of the Conference, the President Yann Pronk qualified the agreement as *historical*. Very few specialists of the climate change issue had expected a positive conclusion from this negotiation round. According to Yann Pronk, the agreement was the result of dialogue and mutual comprehension. The Kyoto protocol formally thought as *deadly collapse* recovered hence a new chance to enter into force in 2002. Few months later, the Marrakech aggreement was signed. A waterdown version of the Kyoto protocol was commonly accepted by most of the countries of the Annex B.

The Framework Convention on Climate Change seems thus to be out of the impass since then. The EU, Japan, Island, Norway and few eastern europe countries already ratified. Breakthrough remains however. In particular one can quote US withdrawal from the process, an effective relaxation of emissions targets for Japan, Canada and Russia, and provision of access to unrestricted emissions trading. The ratification of the Protocol is thus to be conceived as a first step toward an international effort to limit climate change. A range of issues are still at hand and the next negotiation period promisses to be again a long standing pourparler making our approach attractive. Above all, the main drawback to be resolved concerns the biggest polluter participation in emission reduction efforts. On can ask what is the best strategic behavior to follow in order to persuade the US to be back in the climate change wagon?

The model presented in this paper aims precisely at giving a theoretical explanation of the effect of explicit bargaining occuring during CoPs. It explains strategic behaviors allowing for given strategic switches during negotiation rounds. Two main specificities characterize this paper. First regarding agents' economic behavior, the modelling architecture allows to describe situations where players have an incomplete information set. As Lux (1995) method to explain explosion of contagion bubbles, we propose here a fads model in which each country of the negotiation sets his strategy according to an additive learning process expressed via the exerts of influences. On the one hand, the country evaluates strategies'payoffs calculated from a dynamic and sequential model knowing that information is incomplete. This is rational behavior. On the other hand, to capture some information held by other players, the country adjusts his strategy according to other countries strategy, this is influence behavior. Second, regarding the theoretical treatment, an approach derived from stochastic game dynamical equations is presented. The use of the master equation to model strategic switch allows us to capture behaviors which cannot be interpreted with the economics toolbox.

Ranges of issues which can be addressed on the basis of this modelling framework are twofold. Firstfold, it allows to deduce the evolution of strategic behavior switches occuring during each negotiation rounds. This result is particularly appealing given that in the current literature representing negotiation process, the input of negotiation procedures and pourparlers are not considered. Secondfold, it provides a representation of decision making and can be used as a tool to enlighten decision-making. In particular, imitation, persuasion, dissuasion and avoidance behaviors are considered. To be introduced an unusual stochastic treatment based on a generalised Fokker-Planck equation is used. The behaviors considered are grouped into two categories of influence : imitation and avoidance. It follows that according to given deterministic rates, countries can change their mind if their expected payoff is not affected much. They can both mimic the strategy of another player or avoid to play the same strategy than a counterpart. A discusion on influence rates allows us to determine different characteristics of countries'behaviors during the negotiation round. Two characteristics are introduced : inflexible behavior (low imitation rate) and imitative behavior (high imitation rate). A third characteristic is shortly discussed, this is contradiction behavior (high avoidance rate).

A simple simulation is provided in the paper. On the basis of Toth el al (2001) model we present the possible outcomes of both the first and second negotiation periods taking into account influence processes. A principal focus is put on the first negotiation period since on the basis of the Toth el al model, cooperation seems barely impossible at the second period whatever influence is exerted. Regarding the first period, the reference scenario indicates that cooperation is not probable. We showed however that the Kyoto protocol could be saved if the bloc Europe+FSU was inflexible on its cooperation will. This seems particularly relevant in view of the negotiation process since CoP6 at the Hague in November 2000. Indeed, at the end of CoP6, disagreements were numerous and everything could let us think that no agreement could be reached in between the UMBRELLA and the European bloc. Next CoPs demonstrated a strong effort made by Europe in order to save the Protocol. At the beginning of CoP6 bis, Belgium in the name of the European Union declared that Europe was ready to make compromises in order to reach an agreement. Furthemore, during the 5th previous months european delegations were sent in ambassies in order to brief delegates on the necessity to ratify a Protocol. Another mean highlighted by our model to insure cooperation was to have an UMBRELLA group uncertain enough on climate change impacts to be easily influenced and hence to agree on a given cooperative strategy. Again, we can find analogies with last CoPs. Recall that at CoP6, four countries of the UMBRELLA, Australia, Canada, Japan and the United States, emitted strong criticisms on the modalities to implement the Protocol. Compromises were set with Canada and Japan and besides the United States all signed Bonn and Marakech agreements. This is thus a mix in between european inflexibility and UMBRELLA's acquaintance to be influenced which explains the final agreement on the implementation of the Protocol making the architecture of the model presented in the paper highly relevant.

The question of the best bargain behavior allowing for participation of the US remains an open question. In its current form, the simulation provided is not very useful to answer this question. We would need indeed to propose a more disagregated form allowing for simulating interactions in between the many countries participating rather than the three regional blocs. Weight on countries influence could be suggested as well. It will permit to capture the role of structural, unilateral and intellectual leaderships. On the basis of the current model one can already intuitively deduce that the participation of the United States will be the result of inflexible cooperation will from the rest of the world. This will be demonstrated in a near future work.

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