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**The logic of two-level games with endogenous lobbying :
the case of international environmental agreements**

Houda HAFFOUDI, LAEP

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THE LOGIC OF TWO-LEVEL GAMES WITH ENDOGENOUS LOBBYING: THE CASE OF INTERNATIONAL ENVIRONMENTAL AGREEMENTS

Houda HAFFOUDHI[♦] *

Abstract

International environmental agreements (IEAs) are increasingly important in a globalized economy. The aim of our paper is study the effect of political pressure groups-lobbies- on the size and stability of IEAs. To this purpose we use the framework of two-level games to explain how national political situation influences the decisions of governments at the international negotiations arena. We present an endogenous lobbying model in which we assume that lobbies try to influence the policy choice of governments by offering political contribution in return for policy compromise. Indeed, we use the "interest based explanation" of international environmental policy to describe the incentives of countries to join an agreement. This approach classifies countries in four categories: pushers, bystanders, intermediate and draggers. We found that, when government gives the same weight to contribution and to social welfare, the contributions from the industrial lobby give incentives to government (Pushers, intermediate) to participate in the grand coalition making it stable. Our results suggest that in order to sustain the grand coalition, weak global environmental agreements - i.e. those involving small abatement targets- should be negotiated. The result is similar if governments are more interested by political contribution. However, if governments care less about political contribution than about social welfare, industrial contribution is not enough to limit the free riding incentives of each type of government. In this situation, pushers are the more expected to sustain a small stable coalition.

Keywords : non-cooperative game, interest group, coalition theory, environmental Policy.

JEL Classification : C720, D720, D780, Q280

Résumé

Cet article a pour objet d'étudier l'influence exercée par les groupes de pression lors des négociations internationales et son impact sur la taille et stabilité des accords environnementaux internationaux (AEIs). Pour ce faire, nous présentons un modèle de lobbying endogène dans lequel nous supposons que les groupes de pression recourent à la contribution politique pour influencer les choix politiques de leurs gouvernements. Notre modèle montre que, lorsque le gouvernement donne le même poids à la contribution et au bien-être social, la contribution politique du groupe de pression industriel donne assez de

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motivations aux gouvernements pour participer à la grande coalition qui devient alors stable. Nos résultats suggèrent que pour soutenir la grande coalition, des accords environnementaux globaux faibles - ceux qui impliquent des cibles d'abattement faibles -devrait être négociés. Le résultat est semblable si les gouvernements sont plus intéressés par la contribution politique. Cependant, si les gouvernements se soucient plutôt du bien-être social, la contribution industrielle n'est pas assez importante pour limiter les motivations de free riding des gouvernements.

Mots-clés: Jeux non-coopératifs, groupes de pression, théorie de la coalition, politique environnementale.

Classification JEL : C72, D72, D78, Q28

1 Introduction

Some of the most important environmental problems urgently calling for solution are problems related to global pollution. Environmental problems such as ozone depletion, climate change and marine pollution have been the focus of intense negotiations at the international level over the past two decades. International environmental agreements (IEAs) are examples of collective action to tackle such global problems. Beyond their specific interest, these agreements are also important in the context of coalition formation theory. This theory focuses on coalition formation mechanisms, i.e. on the incentives that lead to self-enforcing international environmental agreements and define the number of the signatory countries. The presence of a strong free-rider incentive prevents most IEAs of being stable and/or effective. For studying these problems, non-co-operative game theory has proved to be a very fruitful approach. Furthermore, this approach shows that when countries reach a stable agreement, this involves a small number of participants. Basically, the models of Barrett (1994), Bauer (1992), Carraro and Siniscalco (1992, 1993) and Hoel (1992) employ a stability concept borrowed from the oligopoly literature (D'Aspermont, et al., 1983) where a coalition is said to be stable if no country wants to accede to the coalition (external stability) and no country wants to leave the coalition (internal stability).

All works studying the problem of IEAs stability and abatement level have the inconvenient of assuming that governments maximize welfare function. However, recent events in the international policy arena have illustrated the extent to which organized groups condition environmental policy, both at national and multilateral level. Industry and environmentalist lobbies have been extremely influential. For example, in the USA, they have held different positions on some issues, such as multilateral emission cuts¹. On others, such as the compliance of foreign legislation with American environmental standards, their objectives have often coincided². Thus, we argue that there are political constraints that bind the hands of national governments that participate in the international negotiation process. The aim of our paper is to study the effect of political pressure groups-lobbies- on the size and stability of international environmental agreements.

¹ While green lobbies have exercised "considerable influence on the negotiations" at Kyoto conference in favor of multilateral reductions in greenhouse emissions (Financial times, December 11, 1997), a broad coalition of corporations, unions and economic lobbies has organized " one of the most intensive campaigns ever mounted on a single political issue, seeking to convince that American curbs on greenhouse gas are unfair and damaging to the economy " (Financial Times, September 10, 1997)

² For example, both have demanded compliance of foreign legislation with American environmental standards on incidental catching of dolphins set out in the Marine mammal protection Act.

To analyse government behavior at the international policy, Sprinz and Vaahoranta (1994, 2002) presented the approach of "interest based explanation" They explain that government position can be deduced from information about the country's ecological vulnerability and abatement cost. This analysis suggests that countries will act as « pushers » for substantial emission reduction when their ecological vulnerability to environmental pollution impact is high and their abatement costs for pollutant emissions are low. In contrast, countries characterized by high abatement costs and low ecological vulnerability can be expected to act as « draggers » in such negotiation due to the low benefit-cost ratio of pursuing emission reduction. Countries with both high ecological vulnerability and high abatement cost are caught in between the former two groups as they face an "intermediate" benefit-cost ratio, while countries that are neither affected by the environmental problem nor face high abatement cost will act as bystanders in international environmental negotiation. They expect that pusher countries take more stringent environmental positions than intermediate countries do, while the latter group is expected to favor environmental protection more often than draggers. The likelihood of bystanders' supporting environmental protection should fall between those for pushers and draggers; however, no direct comparison with the intermediate group seems to be appropriate on theoretical grounds. This study give an interesting explanation to government decisions at the international level but present the same inconvenient than the previous works, it doesn't consider national political actors and their effects on government policy.

Since we are mainly concerned with a positive analysis of both coalition formation and the size of a stable IEA, we assume then that authorities, rather than seeking social welfare objectives, pursue their own self-interest motives maximizing their political support. Our paper shares the interest of an increasing political economy literature, which examines the influence of interest groups on policy-making³. Most studies have focused on the role of producer groups in the determination of trade policy. In this area, the political contributions approach of Grossman/Helpman (1994, 1995 and 1996) is a sort of a standard model. A more recent body of literature, which includes Frederiksson (1997), Aidt (1998) and Conconi (2003) studied the political economy of environmental policy. These studies adopt the political contribution approach to study the impact of environmentalists and producer interest on environmental policy. But none examine the effect of lobbying by environmentalists and producer groups on the formation and stability of IEA.

In the majority of recent literature, lobbying is modeled as a "menu auction" where exogenously given lobby groups offer policy makers contribution schedules, representing binding promises of payment, depending on the chosen policy (Bernheim and Whinston 1986, Besley and Coate 2001, Dixit, Grossman and Helpman 1997, Grossman and Helpman 1994 and 1996). In this paper, we propose an alternative model of endogenous lobbying where given the set of existing lobbies; the government chooses the lobbies with which it will bargain over policy in exchange for contribution. (Felli and Merlo 2002, 2003)

The aim of the current paper is to develop an international framework in which the Government's decision about IEAs' participation and abatement level (international level) are influenced by pressures of interest groups who organize a collective action through electoral contributions (national level). It is, therefore, assumed that lobbies try to influence the policy choice of the governments by offering them political contribution in return for policy compromise. To this end, we use the two-level games framework, which acknowledges the interplay between domestic politics and international relations (Putnam, 1988). This paper is, based on the notion that lobby groups pressure constitutes a political constraint that the governments face at home, and shapes the outcome of international agreements. Then, in the

³ See Person and Tabellini (2000), for extensive review of this literature.

national level we have a lobbying game. We have the bargaining game between government and lobby groups presented earlier. Each group propose its political contribution and government try to choose which national political coalition it will choose to maximize its objective function at the international level. Then, government considers lobby support when it decides about both its participation to the international environmental agreement and its abatement level in two following stages. Hence, in the international level, we have the coalition game in which governments decide non-cooperatively whether or not to sign the agreement. Two groups of countries emerge at the end of this stage: the signatories and the non signatories. In the third and last stage, governments play the non-cooperative Nash emission game, where governments, which sign the agreement, play as a single player and divide the resulting payoff according to a given burden-sharing rule.

We organized the remainder of the paper as follows. In section 2, we present the analytical framework. Section 3 sets out the basic model. In section 4, we determine the abatement level equilibrium. In the section 5, we present the results from our stability analysis. In section 6, we report on results of various sensitivity analysis. Section 7 summarizes the main findings, draws policy conclusions and concludes with some remarks about future research issues.

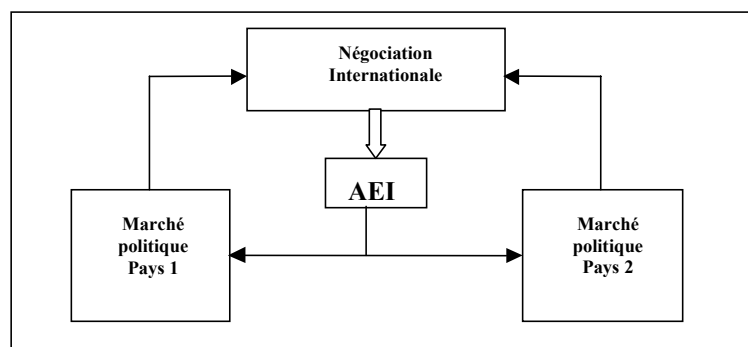
2 An analytical framework

The economic literature on international environmental agreements tends to treat the participant in international negotiations as monolithic and benevolent governments that sincerely represent the common interest of their country (see, eg., Barrett, 1997). While this approach has yielded many important insights, it appears somewhat incomplete and inappropriate, for analyzing the international environmental agreements' size and stability. In particular, it leaves out the idea that governments often have interests opposed or aligned with those of their domestic constituents, and that it is the incentive embodied in elections and other political control systems that ultimately determine what these governments can and will do at the negotiation table. These ideas have long been recognized by political scientists and public choice scholars, and have been formalized in the theory of two-level games.

In most international bargaining situations, negotiators attempt to find an agreement acceptable not only to the foreign countries with which they are bargaining, but also to the majority of their domestic interests. Negotiators often find themselves simultaneously engaging in domestic and international bargaining. Then the goal of this article is to present a formal model which reveals how domestic and international factors interact to shape international environmental cooperation between nations. This model examines the interaction between international environmental negotiations and a simple domestic political situation; it is a two level game. Such games have been discussed before, and a few studies have attempts to formalize the notion (Schelling, 1960; Walton and McKersie, 1965; Evans, Jacobson and Putman, 1993; Putnam, 1988. Formal models include Iida, 1991 and 1993; Mo 1991; Morrow 1991; Lohmann 1993) but rare are those which have studied international environmental negotiations.

As the name of the theory suggests, the game is played at two levels: the international level, where the executives of countries involved in cooperation meet to negotiate the terms of an international environmental agreement, and the national level, where a political market constrains the set of politically acceptable actions available to the national representative during the negotiation at international level. The general structure of this game is illustrated in the following Figure:

Figure 1 : Two-level Games (source: Putman, 1988)



The national political markets impose constraints on the representatives in many ways. We have the electoral incentives of the executive. Because the electorate is not a direct participant, it cannot directly influence the international bargaining, but it can influence it indirectly through election. Then government, in the international bargaining game has to make a proposal that is acceptable to his domestic constituents (Morrow, 1991). While voters are concerned about many different policy issues, they take a basic interest in the issue of environmental problems, although priority placed on it differs between countries (CEU, 1999). Successfully reaching an IEA at the international level is, therefore, important for national politicians who want to demonstrate progress in the implementation of climate policy, for example, and, ultimately, for winning election. The adoption of emissions targets involves, as the same time, the benefits and cost perceived by different voters. Voters may well reward politicians for reaching international agreements, even though the "real" benefits of action against climate change are highly uncertain and would, in any case, not materialize until far into the future. On the other hand, greenhouse gas abatement is costly, and the costs are borne by firms and households immediately. Then when governments seek to implement climate policy, they risk losing votes from voters harmed by abatement decision.

Interest groups affect also government decisions (Olson 1965). Special interest groups: green lobby and industrial lobby- in particular Business associations and environmental NGOs- are able to affect the behavior of politicians by providing information, by financing election campaigns, or by bringing climate change problems to the forefront of the minds of the voter (Grossman and Helpman, 2001).

All these political factors are taken into account when the executives of the countries meet at the international level to decide whether or not they will accept to participate in the IEA, and define the abatement level that individual representatives would consider politically acceptable. The model presented is an example of nested game. We can think of international negotiation as consisting of domestic and international games that are played simultaneously, that is, players take a single action applicable to both games.

3 Model

Consider a world of $i=1, \dots, N$ countries, each of them emits a pollutant that damages a shared environmental resource. Each Government i 's objective function is presented as follow

$$(1) \quad U_i(q_i, q_g) = B(Q) - AC_i(q_i) + \sigma_i \sum_{h \in l_i} C_i^h(q_i, q_g)$$

Where $B(Q)$ denotes abatement benefits, $AC_i(q_i)$ is country i 's abatement cost, q_i is i 's abatement and Q represents the global abatement such that $Q = \sum_i q_i, (Q \leq a)$. $C_{hi} > 0$ represents the monetary contribution given by lobby h to the government. l_i represents the national coalition of interest group with which government prefers to negotiate. $\sigma_i > 0$ measures the intensity of each government's preferences over contribution with respect to environmental policy⁴.

The country i 's current abatement benefits are assumed to depend on current total abatement as follows

$$B(Q) = b \left(aQ - \frac{Q^2}{2} \right) \text{ such that } Q \leq a.$$

Where a and b are positive parameter such that b represents the slope of each country's marginal abatement cost curve.

Each country's abatement costs are assumed to depend on its own abatement level. For country i , the abatement cost function is assumed to be given by

$$AC_i(q_i) = \frac{c}{2} q_i^2$$

The parameter $c > 0$ represents the slope of each country's marginal abatement cost curve. This cost isn't sufficiently high to make producer profit negative.

In this paper, we propose an alternative model of lobbying where the elected policy-maker chooses the lobbies that participate in the policymaking process. This is the sense in which lobbying is endogenous in our model. We assume that given the set of existing lobbies, the government chooses the lobbies with which it will bargain over policy in return for contribution (Felli and Merlo, 2002).

We model environmental policy making as the outcome of a political process that involves not only elected government but also non-elected political agents know as lobbies. We assume that there are 2 lobbies: Environmentalist and industrial respectively E and I which differ with respect to their policy preferences. Each lobby h has a most preferred policy outcome q_I and q_E respectively.

⁴ if $\sigma_i=0$ governments are purely policy-motivated and lobbying is irrelevant, that is the case usually presented in environmental policy literature, where $B(Q) - AC_i(q_i)$ represents country i global welfare. In this case government abate q_g his most preferred policy.

Each lobby h is assumed to be able to sign binding contracts on environmental policy choice with government in exchange for contribution transfers. Notice that the government has the option of not signing any contract and of implementing his most preferred policy q_g .

We suppose that only environmentalists have environmental concerns and that their ideal abatement level is $q_E = \frac{a}{N}$. The environmentalist's current benefit from abatement decision takes the following form:

$$(2) \quad V_i^E(q_i, q_E) = v^E(q_i, q_E) - C_i^E(q_i, q_E)$$

Where $v^E(q_i, q_E) = B(Q) - D_i(q_i, q_E)$. $D_i(q_i, q_E) = \frac{b}{2}(q_E - q_i)^2$, represent the damage generated by the abated emission.

Then, environmentalists' preferences depend on the global benefit generated by the total abatement realized by all countries and on the damage caused by the non-abated emissions consisting in the difference between their ideal point (q_E) and their country current abatement level (q_i).

When environmentalists gain from the increases in total (global) abatement effort, this means that an environmentalist group in a country j will support its own government even though abatement effort has been made in some country i . This means that government will be rewarded by its environmentalist group for having incited other government to participate to the collective abatement effort. But, global benefit isn't sufficient to explain why an environmentalist group is supporting its own government. We assume that it will only do so, when its own government undertakes additional abatement effort. To introduce this condition, we suppose that environmentalists are harmed by the damage caused by the non-abated emissions consisting in the difference between their ideal point (q_E) and their country current abatement level. Then environmentalist group reduces its government support both when government doesn't take any abatement decisions and when its abatement decision is lower than environmentalist ideal abatement level (q_E). Then the more the government abatement level is closed to the environmentalist group ideal point, the more it will be supported.

Industrialist groups are always harmed by their government abatement decisions and their abatement cost is assumed to depend on its own abatement level and not on one else's and it takes the following form:

$$(3) \quad V_i^I(q_i, q_I) = v^I(q_i, q_I) - C_i^I(q_i, q_I)$$

Where $v^I(q_i, q_I) = -AC_i(q_i, q_I)$. $AC_i(q_i, q_I) = \frac{c}{2}(q_I - q_i)^2$ et $q_I = 0$. Then industrialist group abatement cost is no else than its country's abatement costs.

We denote $\Lambda = \{I, E\}$ the set of lobbies. Let

$$\Delta = \{\{\emptyset\}, \{I\}, \{E\}, \{I, E\}\}$$

be the collection of all possible coalition of lobbies with whom government may choose to participate to the IEA and to bargain over abatement policy and contribution.

Each possible coalition $l_i \in \Delta$ is associated with a willingness to pay, $\omega_{l_i}(q_i, q_g)$, for any policy q_i the government may choose to implement instead of his most preferred policy q_g ;

$$(4) \quad \omega_{l_i}(q_i, q_g) = \sum_{h \in l_i} C_i^h(q_i, q_g)$$

such that $\omega_{\{\emptyset\}}(q_i, q_g) = 0$

Given the preferences of a lobby specified is equation (2) above, the willingness to pay of lobby $h \in l_i$ for any abatement policy q_i implemented by government is

$$(5) \quad C_i^h(q_i, q_g) = [v^h(q_i, q_h) - v^h(q_g, q_h)]$$

$C_i^h(q_i, q_g)$ is the monetary value of utility gains (or loss) with respect to the status quo that lobby h obtains if government chooses abatement level q_i instead of its most preferred policy q_g applied in the status quo.

The status quo is here defined to be government decision in absence of any lobbying, q_g .

Given lobby groups preferences specified in equation (2) et (3), each lobby political contribution takes the following forms:

$$C_i^E(q_i, q_g) = B(Q) - B(q_g) + \frac{b}{2} [q_g^2 - q_i^2 - 2q_E(q_g - q_i)]$$

$$C_i^I(q_i, q_g) = \frac{c}{2} [q_g^2 - q_i^2 - 2q_I(q_g - q_i)]$$

The willingness to pay $\omega_{l_i}(q_i, q_g)$ of national political coalition l_i , for any policy q_i that government may choose instead of its ideal policy q_g , takes the following form:

$$(6) \quad \sum_{h \in l_i} C_i^h(q_i, q_g) = \alpha [B(Q) - B(q_g)] + b \left[\frac{1}{2} (q_g^2 - q_i^2) S_1 - (q_g - q_i) S_2 \right]$$

where $S_1 = \sum_{h \in l_i} \frac{b_h}{b}$, $S_2 = \sum_{h \in l_i} \frac{b_h}{b} q_h$ such that $b_h = b$ si $h = E$ et $b_h = c$ si $h = I$. Then, for all

possible coalition of $\Delta = \{\{\emptyset\}, \{I\}, \{E\}, \{I, E\}\}$, S_1 takes as values $\{0, 1, \lambda, 1 + \lambda\}$ with $\lambda = \frac{c}{b}$ et S_2 takes as values $\{0, 1, 0, 1\}$ respectively. The parameter α indicates the existence of the environmentalist lobby group in the national political coalition l_i . $\alpha=1$, if government consider the political contribution proposed by the environmentalist lobby group and $\alpha=0$ if not. Then, for all government political choice there is a willingness to pay.

Our model does not explain the process of lobby formation. We simply assume that only two groups of citizens overcome the free-riding problem described by Olson (1965) and get politically organized: a proportion of the population, the "environmentalists", who form a

national green lobby and the industrialists, who form producer lobby. This model is first concerned with establishing the effects of political support motives on the determination of emission abatement and then the number of countries signing a stable IEA.

4 The equilibrium

Following the approach of the non-cooperative game theory of coalition formation, we assume that countries decide simultaneously in the last two stages of our model. In the first stage-the coalition game- they decide non-cooperatively whether or not to sign the agreement. The equilibrium number of countries participating in an IEA is then derived by applying the notions of internal and external stability of a coalition originally developed by D'Aspremont et al. (1983). In the second stage, they play the non-cooperative Nash emission game, where the countries, which sign the agreement, play as a single player and divide the resulting payoff according to a given burden-sharing rule.

We use a feedback resolution to resolve our two stage non cooperative game. We begin by the determination of signatories and non signatory countries abatement. Then, we determine the size of stable coalition which depends on national lobby support. Finally, we deduce which national political coalition will maximize each government payoff at the equilibrium.

We suppose that there are two groups of countries. We assume that s identical governments sign an agreement and $N-s$ do not. Let Q^s denote the abatement level of the coalition, and q_i^s denotes the abatement of any individual signatory, such that $Q^s = sq_i^s$. In a similar manner, each non-signatory government's abatement is q_i^{ns} yielding a total abatement of all non signatories $Q^{ns} = (N-s)q_i^{ns}$. Global abatement level is $Q = (N-s)q_i^{ns} + sq_i^s$

We assume that countries decide simultaneously in both stages. The non-signatories behave non-cooperatively when signatories choose their abatement level by maximizing their collective payoff function. That is, non-signatories choose q_i^{ns} by solving the following maximization problem.

$$(7) \quad U_{ns}(q_{ns}, q_g) = B(Q) - AC_{ns}(q_{ns}) + \sigma_{ns} \sum_{h \in I_{ns}} C_{ns}^h(q_{ns}, q_g)$$

Explicitly, each non-signatory government objective function takes the following form:

$$U_{ns}(q_{ns}, q_g) = b \left(aQ - \frac{Q^2}{2} \right) - \frac{c}{2} q_{ns}^2 + \sigma_{ns} \sum_{h \in I_{ns}} \left[v^h(q_{ns}, q_h) - v^h(q_g, q_h) \right]$$

The non-signatory abatement level verifies the following equation:

$$(7') \quad MB(Q) + \sigma_{ns} \sum_{h \in I_{ns}} MC_{ns}^h(q_{ns}, q_g) = MAC_{ns}(q_{ns})$$

where MB : marginal global benefit, MC : marginal Contribution and MAC : marginal abatement cost.

Signatory's governments choose Q_s by solving the following maximization problem.

$$(8) \quad \sum_{s \in N} U_s(q_s, q_g) = \sum_{s \in N} \left[B(Q) - AC_s(q_{ns}) + \sum_{s \in N} \left[\sigma_s \sum_{h \in I_s} C_s^h(q_s, q_g) \right] \right]$$

Explicitly, signatory's objective function takes the following form:

$$\sum_{s \in N} U_s(q_s, q_g) = \sum_{s \in N} \left[b \left(aQ - \frac{Q^2}{2} \right) - \frac{c}{2} q_s^2 + \sum_{s \in N} \left[\sigma_s \sum_{h \in I_s} \left[v^h(q_s, q_h) - v^h(q_g, q_h) \right] \right] \right]$$

where $Q = s.q_s + (N-s)q_{ns}$. Government member of the coalition considers not only its national contribution but also contributions received the other member to remain in the coalition. Signatory's governments abatement level verifies the following equation :

$$(8') \quad \sum_{s \in N} \left[MB(Q) + \sigma_s \sum_{h \in I_s} MC_s^h(q_s, q_g) \right] = MAC_s(q_s)$$

Using équations [7'] et [8'], we can resolve the second stage of the game. The result is presented by the following proposition:

Proposition 1 :

Each government abatement level decision depends not only on its national political process but also on the political process in the foreign country. The individual abatement level of signatory and non signatory government take the following form :

$$q_s = \frac{s(1+s\sigma_s\alpha_s)\chi_{ns}}{\varphi} a + \frac{s \left[\sigma_s S_2^s \chi_{ns} + (N-s) \left[(1+\sigma_{ns}\alpha_{ns})\sigma_s S_2^s - (1+s\sigma_s\alpha_s)\sigma_{ns} S_2^{ns} \right] \right]}{\varphi}$$

$$q_{ns} = \frac{(1+\sigma_{ns}\alpha_{ns})\chi_s}{\varphi} a + \frac{\left[\sigma_{ns} S_2^{ns} \chi_s + s^2 \left[(1+s\sigma_s\alpha_s)\sigma_{ns} S_2^{ns} - (1+\sigma_{ns}\alpha_{ns})\sigma_s S_2^s \right] \right]}{\varphi}$$

where

$$\varphi = s^2(1+s\sigma_s\alpha_s)\chi_{ns} + (N-s)(1+\sigma_{ns}\alpha_{ns})\chi_s + \chi_s\chi_{ns}, \chi_s = s.\sigma_s S_1^s + \lambda, \chi_{ns} = \sigma_{ns} S_1^{ns} + \lambda, \lambda = \frac{c}{b}.$$

Hence, for coalition structure s , $\sum_{s \in N} \left[MB(Q) + \sigma_s \sum_{h \in I_s} MC_s^h(q_s, q_g) \right] = MAC_s(q_s)$ holds for a member $i \in c$ in equilibrium and for a singleton j $MB(Q) + \sigma_{ns} \sum_{h \in I_{ns}} MC_{ns}^h(q_{ns}, q_g) = MAC_{ns}(q_{ns})$. Thus, joining coalition s has the advantage that own abatement efforts are matched by other members and hence higher benefits, but also

means higher abatement costs and higher/lower lobby contributions. Both effects determine whether a coalition is stable, which is checked in the following section.

We have always $q^{nc} > 0$ and $q^c > 0$ which guarantees that our solutions are interior. The remaining problem is to determine the number of signatories to the self-enforcing IEA.

5 The size of stable IEAs

We now proceed with the determination of the size of the stable IEA, denoted by s^* , using the internal and external stability conditions. Recall that the internal stability condition ensures that if a government were to defect unilaterally, its gains from free riding would be outweighed by the adjustment (due to its defection) of abatement levels of the remaining members of the IEA. The external stability condition ensures that no other non signatory government finds it beneficial to unilaterally join the IEA; formally, the internal and external stability conditions satisfy this definition:

Definition: An IEA consisting of s signatories is self-enforcing if

$$M^s(s^*) > M^{ns}(s^* - 1) \quad \text{et} \quad M^s(s^* + 1) < M^{ns}(s^*)$$

A full characterization of solution cannot be obtained analytically for this functional specification. However, simulations reveal a very simple and compelling relationship between

$$\sigma_s, \sigma_{ns} \text{ and } \lambda = \frac{c}{b}.$$

We test all coalition structures for stability using our political economy model. To simplify our presentation, we suppose that b takes three values (0.01, 1, 100), c takes as values (0.01, 1, 100). In our benchmark scenario, when governments are immune to the pressure of lobby groups (i.e. $\sigma=0$), it turns out that there are only one stable coalition of small size ($s^*=2$) such that $\lambda > 1$ ($b=0.01$ and $c=100$). There were only internally stable coalitions, but none of these is externally stable. This stresses the presence of strong free-rider incentives in our framework. This situation, however, is different once the government considers political pressure factors - lobby contributions- into its payoff function. In the following we report on the results for this exercise, considering the case of $\sigma_s = \sigma_{ns} = 1$ for both signatory and non-signatory governments.

Figure 2: Stable coalitions under different lobby contributions

		<i>Signatories</i>			
<i>Lobby</i>		\emptyset	Environmentalist	Industrial	Environmentalist and Industrial
<i>Non-signatories</i>	\emptyset	2 (0.01-100)	<i>Grande coalition</i> (0.01-100)	<i>Grande coalition</i>	<i>Grande coalition</i> (0.01-100)
	Environmentalist	2 ($b > c$)	2 (0.01-100)	<i>Grande coalition</i>	7 ou 2 (0.01-100)
	Industrial	2 (0.01-100)	Singleton	2 ou 5 ($b < c$)	Singleton
	Environmentalist and Industrial	Singleton	2 (0.01-100)	<i>Grande coalition</i>	5 (0.01-100)

From figure 2, we can observe that once governments include in their decisions the level of political pressure that the lobby groups exert -in the form of monetary contributions- stability and size of coalition increase. There are no non-trivial stable coalitions in thirteen of our scenarios. Among these, the grand coalition is stable in five of the cases. We also can observe that the extent of this improvement is determined mainly by the decisions of signatories and their abatement and cost characteristics. Indeed, stable coalition, if it exists, happens globally when $b = 0.01$ and $c = 100$.

More specifically, when signatories continue to be immune to lobby influence, small coalition is stable independently of non-signatories' decision about with which lobby they bargain. The situation does not improve much when non-signatories bargain with environmental lobby group or both lobbies; in this case only one possibility gives a large stable coalition, that is when no-signatories are immune to lobby contribution.

If signatories decide to accept only the contributions of the industrial lobby, the stable coalition emerge independently of signatories' decision about with which lobby they bargain. We have coalition of size two and five if signatories have the same national political choice and the grand coalition (i.e. an agreement of all countries) if not. Differently to the others cases, the grand coalition is stable for all values of b and c .

Proposition 2:

Once governments include in their decisions the level of political pressure that the lobby groups exert, stability and size of coalition increase. Basically, industrial lobby contribution reduces the incentive of free riding and can incite signatory governments to sustain the grand coalition when the non-signatory government has different national political preferences.

To explain government decisions which emerge from our model, we have to determine the solution of our to stage game. Figure 2 gives all stable coalitions under different lobby contribution but didn't specify which one maximizes government payoff function. The solution depends on abatement cost and benefit parameters, and is given by table 1.

Table 1. Lobby coalition which maximize government payoff under Stable coalitions

		ecological vulnerability (b)		
		0.01	1	100
abatement cost (c)	0.01	<i>Grande coalition</i>	<u>Grande coalition</u>	<u>Grande coalition</u>
	1	7	Grande coalition	<u>Grande coalition</u>
	100	2	7	Grande coalition

(a)

		ecological vulnerability (b)		
		0.01	1	100
abatement cost (c)	0.01	$\{\{I,E\}, \{E\}\}$	$\{\{I,\emptyset\}; \{I,\{I,E\}\}\}$	$\{\{I,\emptyset\}; \{I,\{I,E\}\}; \{I,\{E\}\}\}$
	1	$\{\{I,E\}, \{E\}\}$	$\{\{I,\emptyset\}; \{I,\{I,E\}\}\}$	$\{\{I,\emptyset\}; \{I,\{I,E\}\}; \{I,\{E\}\}\}$
	100	$\{\{I,E\}, \{E\}\}$	$\{\{I,E\}, \{E\}\}$	$\{\{I,\emptyset\}; \{I,\{I,E\}\}; \{I,\{E\}\}\}$

(b)

Table 1 presents the solution of our game. It gives government decision about its participation to IEA and with which lobby it bargain to maximize its payoff function. The grand coalition, when signatories receive support only from the industrial lobby, represents the solution of our model if b is high and $b > c$. Nevertheless, there are other stable coalitions, namely a coalition of size seven and the singleton coalition, which emerge at the equilibrium, when $b < c$ and signatories are supported by environmental lobby or both lobby.

Government position can first be deduced from information about the country's ecological vulnerability (b) and abatement cost(c) (Sprinz and Vaahtoranta, 1994). By combining these two indicators, governments can be classified into four categories, as follow:

Figure 3: Prediction of interest-based explanation from government negotiating position

		ecological vulnerability	
		Low	High
abatement cost	Low	Bystanders	Pushers
	High	Draggers	Intermediates

Sources : Sprinz and Vaahtoranta 1994, 8

The interest-based explanation proposed by Sprinz and Vaahtoranta (1994, 2002) suggests that countries will act as « pushers » for substantial emission reduction when their ecological vulnerability to environmental pollution impact is high and their abatement costs for pollutant emissions are low. In contrast, countries characterized by high abatement costs and low ecological vulnerability can be expected to act as « draggers » in such negotiation due to the low benefit-cost ratio of pursuing emission reduction. Countries with both high ecological vulnerability and high abatement cost are caught in between the former two groups as they face an "intermediate" benefit-cost ratio, while countries that are neither affected by the environmental problem nor face high abatement cost will act as bystanders in international environmental negotiation.

The interest based explanation allows an initial understanding of possible positions taking by countries in international environmental negotiations. However, it doesn't explain why we have stable coalition when government considers its national political coalition support, whereas, in the base case, (without lobbies' influences) the singleton is the most frequent situation.

Following this approach, we can deduce (from table 1, (a)) that contribution helps to reduce the free rider incentives present in the coalition when countries do not receive any support from lobbies. Countries characterized as pushers do not have any incentive to form a stable coalition in the "base case". However, when countries consider industrial lobby support they are willing to participate to the grand coalition (table 1, (b)). Indeed, each government receives a positive contribution from industrial lobby, because they perform an abatement level lower than that resulting from the scenario (O,O)-henceforth also called as "base case". Given their high level of marginal benefit, pushers are interested in higher levels of global abatement. The level of abatement in the "base case" corresponds to the government's most preferred level of abatement (q_g). The industrial lobby benefits from the decision of countries to have a lower abatement level than in the "base case", hence is willing to make a positive contribution to compensate for the associated costs (table 2).

Intermediates present the same incentive than pushers in the "base case". Considering industrial lobby support they are also incited to participate to a large agreement but given their high level of marginal abatement cost, their abatement level is lower than that of pushers. This ensures that each government receives a level of contribution from the industrial lobby sufficient to compensate it for the forgone benefits due to the lower level of global abatement compared to "base case" situation.

Countries that are expected to act as bystanders do not have any incentive to form a stable coalition in the "base case". Although they may participate to a self-enforcing IEA when they consider industrial lobby contribution (grand coalition, Figure 1), they maximize their gain when they avoid a coalition. Each government prefers to behave as singleton coalition without considering lobby contribution. When they consider both lobbies support, they receive positive contribution from environmental lobby as they abate more than in the "base case" and they lose small support from industrial lobby as, given their small marginal abatement benefit, this increase is small. Globally they gain more in this situation compare to the grand situation when they receive contribution from industrial lobby. However, given their low marginal benefit, bystanders prefer to be immune to lobby influence and not to increase their abatement level. This government maximizes their gain when they remain in the status quo.

On the contrary, draggers may have incentives to participate to an agreement in the base case. In our benchmark scenario, when governments are immune to the pressure of lobby groups, it turns out that the coalition of size two is stable (Figure 2). For instance, given their high marginal abatement cost, each government is interested in low level of abatement and forms a small coalition when costs are very high (with $c=0.01$ and $b=0.01$). When governments consider both lobbies contribution, they receive enough compensation to form a coalition of size seven (table 1, a, b). Given its cost-benefit structure, each signatory's government will abate a medium level of abatement but higher level than q_g . This ensures that, on the one hand, this government receives a high level of contribution from the environmental lobby sufficient to compensate it for the forgone due the higher level of global abatement compared to the "base case" situation; and, on the other hand, they lose a small support from industrial lobby. Globally, draggers receive a positive contribution from both lobbies enough to sustain an agreement.

Proposition 3

The size of stable coalition depends not only on national political coalition but also on benefit cost structure of each government. Considering political contribution, pushers are the most expected to sustain a large coalition (industrial contribution) Draggers are the less expected to form a stable coalition (environmental or two lobbies contribution). Intermediate are caught in between the former two groups (industrial lobby contribution). Nevertheless, each government decision change when it changes its national political coalition.

However, when costs are very high, government expected to behave as draggers maximize their gain when they avoid the agreement. The incentives of free riding are very important in this situation. Although in the base case, we have small stable coalition when costs are high, considering environmental lobby support, the contribution isn't enough to reduce free riding incentives. Given the high marginal abatement cost, each dragger acting as a singleton has incentive to have low level of abatement. Each government receives positive contribution from industrial lobby, due to the lower level of abatement compares to the situation of "base case" sufficient to break the coalition.

Table 2: Results for stables coalitions for each type of government (with and without lobby contributions)

Countries	Abatement (no contributions)	Abatement (with contributions)	net Gain (no contributions)	net Gain (no contributions)	Contributions
Pushers ^{(a)*}	-	9,999	-	5 10 ⁷	C _I ^s =0,01 10 ⁻²
	9,9999	-	49 999 950	-	
Intermediates	999,990	999,900	-	4,9999 10 ⁷	C _I ^s =0,9704
	-	9,9	-	-	
Draggers(1)	9,901	-	49 500 099	-	C _E ^s = 691,66 C _I ^s =-4,81 C _E ^{ns} = 691,69
	990,100	990,000	-	5,1111 10 ³	
	-	5,884	-	5,1107 10 ³	
Draggers (2) ^(b)	5	6,716	3737	-	C _E ^s = 95,32 C _I ^s =-0,37 C _E ^{ns} = 95,33
	500	665,819	-	287,92	
	0,198	0,131	98,50	287,22	
Bystanders	0,099	0,197	99,97	-	C _E ^s = 0,3583 C _I ^s =-0,0048
	10,097	19,575	-	49,9974	
	-	9,950	-	-	
Bystanders	9,901	-	50,0051	-	
	990,100	995,000	-	-	

*: Similar result for the other cases. ^(a): caes b=100 and c=1, ^(b): case b=0,01 and c=100, Draggers (1):the two other cases, -: don't exists

Table 2 gives the abatement level and payoff for signatories (grand coalition) and/or non signatories (small coalition or singleton coalition respectively) and the total abatement level in the case of small coalition. From table 2, it is evident that without the contribution of the industrial lobbies the grand coalition is not stable. Pushers gain more than intermediates by participating to a large agreement. Draggers are the most gainer by sustaining a self-enforcing IEA when they consider both lobbies contribution. In addition, we find that pusher countries take more stringent environmental positions than intermediate countries do, while the latter

group is expected to favor environmental protection than draggers. The likelihood of bystanders' supporting environmental protection fall between those for pushers and draggers; however, no direct comparison with the intermediate group seems to be appropriate on theoretical grounds.

Proposition 4:

A large stable coalition corresponds to a weak agreement - an agreement that not involve a high level of abatement. Compare to the status quo. A stringent environmental agreement, if they emerge, will be sustained only by a small number of countries.

All regions, with the exception of part of draggers, would gain by leaving the coalition and becoming free riders. If countries do not respond to political pressures, and given their benefit and cost structure, the increase in abatement efforts when joining the coalition will impose them a severe burden that is not compensated by the augmented global benefits. Bystanders are always interested in acting as a singleton with and without lobby influence whereas draggers have the same incentives when their abatement costs are high.

The situation changes once countries accept the contributions from the industrial lobby (pushers and intermediate) or both lobbies (draggers). No country has an incentive to leave the coalition. This result might appear strange given that the industrial lobby is interested in having the lowest abatement possible. But there are two factors that help to rationalize this outcome: the change in the abatement efforts and the increase in payoffs due the contributions. As we can observe abatement levels are lower in the case when countries only bargain -and receive contributions- from the industrial lobby. When governments are expected to behave as draggers, they receive globally a positive contribution from both lobbies enough to compensate the increase to the cost due to the increase in the abatement.

6 Sensitivity Analysis

A typical feature of simulation method is that results depend on parameter values, which are subject to some uncertainty. Given the large number of parameters that enter our model, some selection is necessary for a sensitivity analysis. We believe that there is high uncertainty concerning the weight given by each government to political contribution compared to social welfare from abatement level and to that given by lobby group. Hence, we conduct a sensitivity analysis where we change the value of δ . For instance, to capture the idea that government cares relatively more about contribution than about social welfare, we assume that $\delta > \mu$. As $\mu=1$, high δ means that government are more interested by political contribution than lobbies. Then, we consider three cases to analyze the influence of government preferences on their decision at the international environmental negotiation. That is, we consider: $\delta_s=0.2$ & $\delta_{ns}=0.5$; $\delta_s=1.5$ & $\delta_{ns}=2$ and $\delta_s=1.5$ & $\delta_{ns}=0.5$; to study the sensitivity of our stable coalitions. These three cases represent respectively the situation in which both signatories and non signatories care relatively less about contribution than about environmental policy compared to lobbies, the situation in which they care more about contribution than about environmental policy and the situation in which signatories are more interested by contribution where non signatories care rather about its social welfare from abatement level.

Proposition 5:

Government decision at the international environmental negotiation depends not only of its benefit cost structure but also on the weight that it gives to political contribution compared to social welfare. Industrial lobby contribution reduces government incentives to behave as free rider. Nevertheless, the size of stable coalition is small if governments are more interested by social welfare and the grand coalition is stable if governments are rather interested by political contribution. In addition, if signatory and non signatory present different political weight, pushers are the more expected to sustain a large stable coalition; whereas draggers form a stable partial coalition if they receive a enough contribution from environmental lobby group to compensate their high cost.

Table 3. Lobby coalition which maximize government payoff under stable coalitions (scenario $\delta_s=0.2$ & $\delta_{ns}=0.5$)

		ecological vulnerability (b)		
		0.01	1	100
abatement cost (c)	0.01	<i>Singleton</i>	<u>2</u>	<u>2</u>
	1	Singleton	Singleton	<u>2</u>
	100	3	Singleton	Singleton

First, not only for our base case but also for the scenarios ($\delta_s=0.2$ & $\delta_{ns}=0.5$) no large coalition is stable regardless of the definition of stability. Only pushers sustain a stable coalition of size equal 2⁵ (table 3). The abatement policy applied in this situation is lower than that of status quo. Although pushers receive positive contribution from industrial lobby, this compensation is not enough to avoid the free riding incentives of each government. Differently to the situation where governments give the same weight to social welfare and contribution, event if governments have the same lobby support, the fact that they are more interested by environmental policy can not give incentive to government, especially pushers, to sustain a large stable coalition.

Table 4. Lobby coalition which maximize government payoff under Stable coalitions (scenario $\delta_s=1.5$ & $\delta_{ns}=2$)

		ecological vulnerability (b)		
		0.01	1	100
abatement cost (c)	0.01	<i>Singleton</i>	<u>Grande coalition</u>	<u>Grande coalition</u>
	1	Singleton	Singleton	<u>Grande coalition</u>
	100	14	Singleton	Singleton

⁵ The same result when signatories continue to give low weight to contribution compared to non signatories (0.5, 1.5) or (0.5, 1). Except for pusher, we have partial stable coalition ($s = 48$ or 28 respectively) when signatory receive contribution from industrial lobby and non signatories from environmental lobby

Second, when governments give more weight to contribution over environmental policy ($\delta_s=1.5$ & $\delta_{ns}=2$), the grand coalition is often stable⁶(table 4). Basically, intermediates and bystander have the same incentives to form a grand coalition and they maximize their payoff if they receive contribution from industrial lobby. Concerning draggers, when they have high cost they maximize their gain when they accept the contribution from industrial lobby and in this case the grand coalition is stable. Given their cost benefit structure and the weight that they give to contribution, draggers receive enough compensation from industrial lobby group to remain in the coalition. Lobbies transfer reduces in this situation the incentives of free riding very important in the case of draggers. Contrary to the case ($\delta_s=1$ & $\delta_{ns}=1$) partial cooperation is not stable and environmental lobby contribution maximize the gain of draggers but is not enough to give them incentive to remain in the coalition. Pushers will realize the same gain both in the situation of small stable coalition ($s=2$), when signatory are immune to lobby influence and non signatory receive environmental lobby support (O,E) and in the situation of grand coalition $s=GC$ where signatory receive support from industrial lobby group independently of non signatory choice. Pushers are indifferent between the two situations, because they don't change their behavior of abatement.

Table 5. Lobby coalition which maximize government payoff under Stable coalitions (scenario ($\delta_s=1.5$ & $\delta_{ns}=0.5$))

		ecological vulnerability (b)		
		0.01	1	100
abatement cost (c)	0.01	<i>Singleton</i>	<u>Grande coalition</u>	<u>Grande coalition</u>
	1	Singleton	Singleton	<u>Grande coalition</u>
	100	14	Singleton	Singleton

Third, the result is closely related to the second point. A conclusion that has been derived from the situation in which signatory are more interested by contribution than non signatory, is that the grand coalition is stable when government receive contribution from industrial lobby (table 5). Pushers, given their high marginal benefit, sustain a large coalition. Concerning intermediates and bystanders they may form a large partial coalition but these coalitions are only internally stable. Finally draggers, given their high marginal cost, they may sustain a stable coalition ($s=14$) if they receive positive contribution from environmental policy enough to compensate the cost related to the increase in their abatement level.

Globally, in the different case presented earlier government has incentives to consider lobbies contributions and then to remain in the coalition. Pushers adopt less stringent environment policy than in the situation without contribution (Table 6). Then, they globally form a large coalition. Draggers have to reduce higher level of pollution than in the situation without national support. They receive high level of contribution from their environmentalist lobby groups enough to compensate their abatement costs and to increase their gains.

⁶ The result is the same for all situation in which signatory give more weight to contribution than non signatory (1.5, 1), (1.5, 1.5), (2, 1.5).

However, lobby groups political support isn't sufficient to reduce government incentives to behave as a free rider. Then, only small coalitions emerge at the equilibrium

Table 6: Sensibility analysis

cases	Countries	Abatement (no contributions)	Abatement (with contributions)	net Gain (no contributions)	net Gain (with contributions)	Contributions
$\sigma_s=0,2$ & $\sigma_{ns}=0,5$	Pushers ^{(a)*}	- 9,9999 999,990	9,995 10 999,990	- 49 999 950	$5 \cdot 10^7$ -	$C_I^s=0,01 \cdot 10^{-2}$
	Intermediates	- 9,901 990,100	--	- 49 500 099	--	--
	Draggers (1)	- 5 500	No	- 3737	No	No
	Draggers (2) ^(b)	0,198 0,099 10,097	0,357 0,099 10,867	98,50 99,97	101,26 105,61	$C_E^s= 1,52$
	Bystanders	- 9,901 990,100	--	- 50,0051	--	--
$\sigma_s=1,5$ & $\sigma_{ns}=0,5$	Pushers ^(a)	- 9,9999 999,990	9,9988 - 999,8803	- 49 999 950	$5 \cdot 10^7$ -	$C_I^s=0,003$
	Intermediates	- 9,901 990,100	No	- 49 500 099	No	No
	Draggers (1)	- 5 500	No	- 3737	No	No
	Draggers (2) ^(b)	0,198 0,099 10,097	3,309 0,142 58,517	98,50 99,97	725,19 801,81	$C_E^s= 704,89$ $C_E^{ns}= 234,77$
	Bystanders	- 9,901 990,100	No	- 50,0051	No	No
$\sigma_s=1,5$ & $\sigma_{ns}=2$	Pushers ^(a)	- 9,9999 999,990	9,9985 - 999,8490	- 49 999 950	$5 \cdot 10^7$ -	$C_I^s=0,0076$
	Intermediates	- 9,901 990,100	9,8512 - 985,1246	- 49 500 099	$4,9984 \cdot 10^7$ -	$C_I^s=73,6915$
	Draggers (1)	- 5 500	No	- 3737	No	No
	Draggers (2) ^(b)	0,198 0,099 10,097	0,1638 - 16,3818	98,50 99,97	255,8008 -	$C_I^s=95,9353$ $C_E^s= -1,2775$
	Bystanders	- 9,901 990,100	9,8512 - 985,1246	- 50,0051	$49,9984 \cdot 10^3$ -	$C_I^s= 0,0074$

* : situation $b=100$ et $c=1$. Similar result for the other cases. No : means no stable coalition, -- : the same result than the situation without contribution.

7 Conclusion

We studied the effect of political pressure groups -lobbies- on the size and stability of global environmental agreements. To this purpose we use the framework of two-level games to explain how the national political situation influences the decisions of governments at the international negotiations arena. In this framework, at the first level of the game (the international) government representatives negotiate the terms of an international environmental agreement. At the second level, the national, is determined the set of politically acceptable actions, available to the national representative during the international negotiations.

We assumed that national political markets are represented by pressure groups --i.e. lobbies. Governments choose whether to bargain or not with a lobby, if they decide to bargain with a lobby they can accept contributions from one or more lobbies at the time. We consider that there are only two lobbies with which governments can bargain: environmentalist and industrial. We consider that the level of contributions depends on each lobby's preferences and the abatement strategy chosen (at the international level) by the government. For the environmentalist lobby, we assumed that its preferences depend on the global abatement efforts and the additional abatement efforts undertaken by the government --with respect to the environmentalist ideal point. For the industrialist lobby, we assume that they are always harmed by their government abatement decisions and thus the level of total abatement costs resulting from the strategy chosen by their government determines its preferences.

We consider a three stage game. In the first stage, we have a lobbying game. In this stage, we have the bargaining game between government and lobby groups presented earlier. Each group propose its political contribution and government try to choose which national political coalition it will choose to maximize its objective function at the international level. Then, government considers lobby support when it decide about both its participation to the international environmental agreement and its abatement level in two following stages Hence, in the second stage, we have the coalition game in which governments decide non-cooperatively whether or not to sign the agreement. Two groups of countries emerge at the end of this stage: the signatories and the non signatories. In the third and last stage, governments play the non-cooperative Nash emission game, where governments, which sign the agreement, play as a single player and divide the resulting payoff according to a given burden-sharing rule.

To analyze government behavior at the international negotiations and its decision to participate to the IEA, we use the approach of "interest based explanation" of international environmental policy. Following this approach and considering the information from our empirical model in term of ecological vulnerability (marginal benefits, b) and abatement costs (c), we classified governments into four categories that correspond to their positions at the international environmental negotiation: pushers, draggers, intermediates and bystanders.

There are four key results from our analysis. First, the inclusion of political pressure factors helps to improve one of the rather "pessimistic" results common to the literature of coalition formation and IEAs: only small coalitions are stable. In our analysis, there was an important improvement from our benchmark scenario --when governments are immune to political pressures- where we did not find any stable coalition. This situation changed once the contributions from lobbies are included in the governments' payoff function. We found that the grand coalition, when signatories receive support only from the industrial lobby, is stable. Thus, contributions help to reduce the free rider incentives present in the grand coalition when countries do not receive any support from lobbies- that we labelled as "base case".

Second, industrial lobby support helps to reduce free-rider incentives present in our "base case". When countries form the grand coalition, the industrial lobby benefits from the

decision of each country to have a lower abatement level than in the "base case", hence is willing to make a positive contribution to compensate for the associated costs. We observed that both pushers and intermediate countries present an incentive to participate in an agreement. The countries characterized as draggers and bystanders do not have any incentive to form a stable coalition in the "base case". Draggers have an incentive to avoid joining the coalition, given its high MAC and low MB levels. The situation changes once lobby contributions are considered. These countries would like to have a small abatement level whenever they are coalition members. As the abatement level is lower than in the "base case", the contributions compensate this type of countries and give them an incentive to stay in the coalition.

Third, in order to sustain the grand coalition, weak agreements would be negotiated. More precisely, when signatories decide to bargain only with the industrial lobby, interested in having the lowest abatement possible, they will receive enough contributions to sustain an agreement that not involve a high level of abatement -i.e. a weak IEA. We found that, the global abatement level, when the grand coalition is stable, is lower than what this coalition would obtain in our "base case". Hence, we can conclude that to have a large stable coalition, countries (especially pushers) must accept a weak IEA. Hence, stringent environmental agreements, if they emerge, will be sustained only by a small number of countries.

Finally, government decision at the international environmental negotiation depends not only of its benefit cost structure but also on the weight that it gives to political contribution compared to social welfare. Industrial lobby contribution reduces government incentives to behave as free rider. Nevertheless, the size of stable coalition is small if governments are more interested by social welfare and the grand coalition is stable if governments are rather interested by political contribution. In addition, if signatory and non signatory present different political weight, pushers are the more expected to sustain a large stable coalition; whereas draggers form a stable partial coalition if they receive a enough contribution from environmental lobby group to compensate their high cost.

Regarding future research, we propose two main extensions: First, we can employ a voting game theoretic model to characterize the stability of such agreements when each country's participation is conditioned upon a domestic ratification vote. Second, our analysis could be extended to cover transfer mechanisms. It would be interesting, considering our framework, to find the effect of the transfers on the result of the international environmental negotiation and the size of stable IEAs that may emerge.

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