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# Heterogeneity, climate change, and stability of international fiscal harmonization

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## SUMMARY

This paper analyses harmonization on fuel taxes between two coalitions. Harmonization is considered as a tool to mitigate greenhouse gas emissions, and reduce environmental costs. Domestic fuel producers can sell abroad, and their profits influence national governments in the negotiations. If all countries are identical, harmonization is environmental friendly provided environmental marginal damages are high. It is also economically profitable, but may be unstable if one of the coalitions is small enough. In this case, however, financial transfers between coalitions can stabilize harmonization. Nevertheless, countries can be heterogeneous with respect to the existence of a domestic producer. Heterogeneity introduces a new instability: not only the size, but also the composition of coalitions matters. Furthermore, the level of environmental damages also influences the stability of harmonization. In this case, intra- and inter-coalition financial transfers are necessary but not sufficient to stabilize harmonization.

**KEY WORDS:** Fiscal harmonization; Climate Change; Coalitions; Stability.

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## 1. INTRODUCTION

Climate change is expected to induce important adaptation costs for human societies in the coming decades. Anthropogenic Greenhouse Gas (GG) emissions related to economic activities are responsible for those future changes (IPCC, 2001). The effect of GG in the atmosphere does not depend on the country where these gases come from. Thus, limiting GG emissions is a global good. Countries who mitigate their emissions do not internalize the environmental benefits they provide to other countries. If no international coordination is implemented, we can expect the level of global emissions to be more important than the optimal level of emissions. Of course, if such coordination does take place, free-riding behaviors can arise.

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The Earth Summit held in Rio in year 1992, and the Kyoto Protocol, have given the birth to a process through which countries are trying to set a common framework for action. Historical reasons have led countries to coordinate their efforts through a quantity-based approach: countries agree on mitigation targets they specify as emission allowances for a nation or a group of nations (e.g. the European Union). Yet the price-based approach, *i.e.* an international tax system on carbon emissions, has not been definitely given up, in the present as well as in a future framework. Several reasons explain this persistence:

- For the time being, national and sectoral policies are specified by governments at the national level, who can choose the tools they will use (tax, regulation, emissions trading, voluntary agreements ...). Due to practical reasons, a carbon tax may prove particularly relevant in some industrial sectors (e.g. the transportation sector, where emitting sources are numerous and mobile).
- It has not been decided yet which approach would be used at the international or national levels in the future (after year 2012): tax instruments still have the support of professional economists for efficiency reasons (Hoel, 1991); furthermore, no agreement has been reached with developing countries on a rule for emission rights allocation.

As a matter of fact, EU uses fiscal harmonization on energy as a tool to reduce emissions from the transportation sector<sup>2</sup>. Fiscal harmonization has been analysed in the economic literature, see for instance Cremer & Gahvari (2005). A part of this literature is focused on the importance of trade for the environmental output (see Ulph, 1997 for a survey of economic papers on trade and the environment, comparing cooperative and non-cooperative outcomes). Meanwhile, numerous articles cope with endogenous coalition formation on climate change mitigation (see for instance Hoel & Schneider, 1997; Greenberg, 1994; or Tulkens, 1998). As a rule, according to this stream of literature, only small groups of countries may reach an agreement (Pereau & Tazdait, 2001).

On the specific topic of the mitigation of greenhouse gas emissions, economists have pointed out important precautions concerning the use of a carbon tax.

The procedural efficiency of a unique tax level has been questioned for acceptability problems. Though it provides a clear signal, it requires financial transfers between countries (Barrett, 1992). Otherwise, due to heterogeneity in countries income levels, in the access to abatement technologies, in the urban and transportation infrastructures, and country-specific side effects of a carbon tax, economists recommend the use of differentiated tax levels as the most efficient tool (Hourcade & Gilotte, 2000). The same problem applies to emissions trading schemes, since quantity and price approaches are dual variables: the allocation of initial emission rights in the quantity approach corresponds to the financial transfers in the price approach (Hoel, 1991).

Second, the question of the possibility of financial transfers has deeper implications than the efficiency problem, namely for the stability of international agreements, and thus for the environmental outcome of international negotiations. Some countries may have an incentive to free-ride, and let other implement a carbon policy. Financial transfers, however, may ensure that a global scheme is implemented, where there are neither losers nor free-riders. Germain, Toint, Tulkens & de Zeuw (2003), and Eyckmans & Tulkens (2003) find a transfer scheme with a core property.

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<sup>2</sup> As stated by the 2003/96/EC Council Directive: “As a party to the United Nations Framework Convention on Climate Change, the Community has ratified the Kyoto Protocol. The taxation of energy products (...) is one of the instruments available for achieving the Kyoto Protocol objectives.” Whether this harmonization process may or may not help reaching EU carbon emissions targets is the focus of a lively debate (Kouvaritakis, Stroblos, Paroussos, Revesz, Zalai & Van Regemorter, 2005).

This paper analyses fiscal harmonization on a carbon-intensive good as a tool to coordinate international actions. It focuses on the instability introduced in the agreements by the heterogeneity of countries. The countries we consider are heterogenous with respect to the existence of a domestic industrial sector producing a carbon-intensive good. We focus our analysis on fuel, which illustrates this kind of heterogeneity<sup>3</sup>. An originality of our paper is that it represents the interactions between national producers and international policies, since governments take into account firms selling their products in all countries<sup>4</sup>. This interaction of national and international levels is rarely present in economic literature (with the noticeable exception of Putnam, 1988).

We also analyse the importance of knowledge and beliefs on environmental costs. In our paper, unlike in Hoel (1992) for instance, the level of the tax is endogenously determined, and takes environmental costs explicitly into account. The estimations of environmental costs interact with the outcome of the negotiations.

We consider two pre-existing coalitions of countries that can use global fiscal harmonization as a tool to mitigate greenhouse gas emissions, or stay in a *status quo*. We show that: when all countries are identical, (1) as soon as environmental costs are high enough, environment protection comes as a by-product of fiscal harmonization; (2) though small coalitions have an incentive to refuse harmonization, financial transfers exist that preserve the stability of harmonization, without any country being worse off than in the *status quo*. If countries are heterogenous, however, (3) instability of the international agreements is greatly enhanced; not only the size, but also the composition of the coalitions matter for the stability of harmonization; (4) financial transfers inside a coalition, or from a coalition to the other, have not necessarily the power to stabilize harmonization.

Furthermore, (5) in both cases (homogeneity and heterogeneity), the value of environmental costs impacts the design of the financial transfer scheme, and influences the feasibility of those transfers. In this paper, we always assume that there is a consensus on this variable.

The remainder of this article is organized as follows. Section 2 presents the general model, and the assumptions about industrial organization, that we use, as well as the economic agents that influence the negotiation process. In Section 3 we lay out the game theory framework we use to represent the incentives to implement global fiscal harmonization. We also introduce several notions of stability of the harmonization process. Section 4 explores analytically the case where all countries are identical: we evaluate the stability of harmonization compared to the *status quo*, and assess the potential for stabilizing financial transfers' schemes. Numerical simulations are then used in Section 4, where the case of heterogenous countries is considered. Section 6 concludes by discussing the results, and providing insights for future research.<sup>5</sup>

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<sup>3</sup> For instance, countries are very heterogenous with respect to the quantity of oil reserves they own. Coal reserves are another interesting example of heterogeneity: four of the six countries who signed the Asian-Pacific Partnership are among the five biggest world coal reserves. Meanwhile, in EU only Germany and Poland have reserves of coal bigger than 10 000 millions of tons.

<sup>4</sup> Accounting for firms' interests also gives insights on the possible effects of lobbying. Indeed, in the real world, firms' profits are not lump-sum redistributed to citizens, and there is no reason to put the same weight on firms' profits as on the consumers surplus.

<sup>5</sup> In the remainder of this paper, we will choose parameters so as to assure that an inner equilibrium exists: quantities sold and traded as well as taxes shall be strictly positive. We will assume that the level of marginal environmental cost  $s$  is high enough, so that governments should have an incentive to set those positive taxes.

## 2. THE GENERAL MODEL

We consider  $N$  countries, and one good consumed and traded between those countries<sup>6</sup>. In each country  $i$ , there are national consumers. In some of those countries, there is also a domestic producer of the good. We will call those countries the “producing countries”, and assume that there is a number  $P \leq N$  of producing countries. The other countries will simply be called the “non-producing countries”.

The domestic producer of country  $i$  can sell a part of its production to the consumers in any other country without extra production costs (transportation costs from one country to another are assumed to be zero). We assume that all consumers have the same preferences and that the national markets are perfectly separated. Thus, the demand functions in any of the countries are exactly the same.

### *Producers*

The cost function of each producer is given by  $C(Q) = 1/2cQ^2$ . Producer  $i$  sells in each country  $j$  a quantity  $q_{ij}$  of the good, and maximizes its profit  $\pi_i$  with respect to the vector  $(q_{ij})_{j \leq N}$ . This profit is given by:

$$\pi_i \left[ (q_{ij})_{i,j \leq N}, (t_i)_{i \leq N} \right] = \sum_{j \leq N} [P(Q_j)q_{ij} - t_j q_{ij}] - c \sum_{j \leq N} q_{ij},$$

where  $Q_j = \sum_{i \leq N} q_{ij}$  is the quantity of the good consumed in country  $j$ . For simplicity's sake, and without any loss of generality, we will consider  $c = 0$  in the remainder of this paper.

A firm is considered as national in the sense that its interests are taken into account by the concerned government. If only, this is so because all shareholders of the firm are from the same country  $i$ . Other grounds support this view: unemployment problems, or the firms' profits are a source of fiscal benefits for the government, or this production is important for strategy reasons. However, the “national dimension” of a firm does not affect the price it sells the good at home or in other countries. No border taxes, no transportation costs increase the prices abroad.

The absence of border taxes has an important implication: in a given configuration, the profits of a producer are the same whatever its country is. In this sense, producers' profits are strongly related to international agreements, but are almost disconnected from domestic interests.

### *Consumers*

The national markets for the good are assumed to be separated, and demand function in country  $j$  is given by:  $P(Q_j) = a - Q_j$ , where “ $a$ ” is a fixed parameter. The aggregate surplus of the consumers in country  $j$  is given by:

$$SC_j = \int_0^{Q_j} P(q) dq - P(Q_j)Q_j = \frac{Q_j^2}{2}.$$

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<sup>6</sup> We analyse climate policies in the transportation sector, and focus our analysis on fuel production and consumption. Our theoretical framework may be applied to other goods as well, so we will refer to “the good” in what follows. Fuel is a standardized good, meaning that there are several fuel categories, but each company provides the consumer with the same quality of a given fuel category. For simplicity's sake, we consider here only one kind of fuel.

All consumers are supposed to have the same preferences in all countries. The only consumption variation we take into account is the fuel consumption, assuming everything else equal.

### *Environmental costs*

Global warming mitigation is a common good as established by the International Panel on Climate Change (see for instance IPCC, 2001). Greenhouse gas emissions cause the same adaptation costs in a given country wherever they come from. Adaptation impacts, however, will be differentiated throughout the world. Unfortunately, the results of the climate models get more and more uncertain as the geographical relevant scale gets more local. It is very difficult, therefore, to predict exactly to what extent global warming will impact Europe, and it is even more difficult to forecast the differences of the magnitude of future damages in France and in Germany for instance.

Thus, we consider that the consumption of one unit of the good induces the emission of a given quantity of the greenhouse gas  $CO_2$ . This emission has a cost  $s$ , supported by each country. It represents the adaptation costs that the quantity of greenhouse gas emitted will entail for the economy of each country; we assume that adaptation costs are the same in any country.

We assume that all countries base their policies on the same estimation of  $s$ , and we refer to the quantity  $s.Q$  as “environmental costs”. This is a strong assumption, considering the uncertainties surrounding the climate models as well as the economic models.

### *Governments*

The government of country  $j$  sets a consumption tax level  $t_j$ , and maximizes a welfare criterion given by:

$$W_j = (\pi_j + SC_j) + (t_j Q_j - s.Q).$$

In this expression,  $(\pi_j + SC_j)$  stands for the individual surplus of both producers and consumers: if the country  $j$  is a non-producing country, then  $\pi_j = 0$ . Meanwhile,  $t_j Q_j$  is the fiscal product, and  $s.Q$  is the climate-related cost of global emissions. Thus,  $(t_j Q_j - s.Q)$  is the net fiscal income of government  $j$ .

We assume that the governments put the same weight on their net fiscal income and on the situation of the other national actors (namely consumers and producers). As we will see below, harmonization implies generally higher taxes than the *status quo*. Producers have an interest into low taxes not only at home, but also abroad, so as to increase their profit. Meanwhile, the net fiscal income of a government gets higher when adaptation costs are low, and tax product is high. This may threaten the stability of harmonization.

We do not take into account the possibility of environmental dumping: consumers in one country can import the good from another country, but this good is not cheaper, since the only fiscal regulation consists in a tax on consumption<sup>7</sup>.

<sup>7</sup> Thus, tax competition in our paper is not necessarily equivalent to tax evasion, an effect that appears often in other papers (see for instance Cremer and Gahvari (2000)), but that is not at the core of our preoccupations.

### 3. FISCAL HARMONIZATION: THE THEORETICAL FRAMEWORK

We present here a conceptual framework designed to investigate the stability of the outcome of the climate negotiations process if coalitions are grouped into coalitions<sup>8</sup>: we assume that the countries enter the bargaining process not as isolated individuals but as coalitions made up before the beginning of the round negotiation (we call such a coalition an *ex ante* coalition). More precisely, we assume that there are two *ex ante* coalitions  $\{E_1, E_2\}$ , with  $|E_i| = e_i$ , that should verify:  $e_1 + e_2 = N$

In the absence of any agreement on harmonization, we assume that both coalitions are in a *status quo*. In the status quo, the coalitions set their taxes  $(t_1, t_2)$  in a co-operative way inside the coalition (by maximizing the surplus of all their members) but in a non co-operative way with respect to the other coalition.

The players inside each coalition agree on common negotiation positions, and delegate their decision (to accept the cooperative agreement or not) to the coalition.

We consider that coalitions and firms play a game  $\Gamma$  given by the two following stages:

- In the first stage, coalitions choose their tax level  $t_i$ ;
- In the second stage, producers  $i$  ( $i=1, \dots, P$ ), observing those national tax levels, choose the quantity  $q_{ij}$  they will sell in each country  $j$ . All quantities are chosen simultaneously.

Formally, in the first stage, the countries grouped in a coalition  $E$  set a tax level solving the following program:

$\max_{(t_j)_{j \in E}} \sum_{j \in E} W_j \left[ q^* \left( (t_j)_{j \in E}, (t_h)_{h \in N \setminus E} \right) \right]$ , where  $q^* \left( (t_j)_{j \in E}, (t_h)_{h \in N \setminus E} \right)$  is the matrix of the quantities produced and traded at the equilibrium corresponding to tax levels set in first stage.

The global cooperation (final *cooperative structure*) arises when the wide coalition  $E_1 \cup E_2$  adopts a cooperative tax, *i.e.* an identical tax for all the countries belonging to  $E_1 \cup E_2$ . The players inside each coalition agree on common negotiation positions, and delegate their decision (to accept the cooperative agreement or not) to the coalition.

Meanwhile, the *status quo* corresponds to a two-stage adhesion game  $(N, E_1, E_2)$ :

Stage 0: The *representatives* of the integral coalition  $E_1 \cup E_2$  propose a level of harmonized tax (agreement).

<sup>8</sup> The Kyoto Protocol has been ratified by 161 countries; negotiations extend to other countries as well at the so-called Conferences of the Parties, occurring once a year. Most countries are grouped in coalitions and negotiation process became a discussion between several groups more or less solid (the 25 EU members, the Umbrella Group, Alliance of Small Island States, ...).

Stage 1: The *coalitions*  $E_i, i=1,2$  decide simultaneously to accept or to refuse the cooperative tax level.

Stage 2: If  $E_1$  and  $E_2$  accept the cooperative tax level, the harmonization is adopted, if one of the two coalitions  $E_1, E_2$  refuse this tax, the coalitions play the non cooperative sub-game  $\Gamma$ .

Anticipating those results, each coalition  $E_i, i=1,2$  decides to accept the harmonization tax or not. To do so, it compares the welfare that it obtain at the equilibrium of sub-game  $\Gamma$  (played only by two players  $E_1$  and  $E_2$ ).

We are interested in evaluating the possibility of success of the global harmonization. In other words, we have to test if harmonization can be equilibrium of the preceding game of adhesion.

The harmonization may not be the “natural” outcome of the game we have presented, *i.e.* one or two of the coalitions may have an incentive to stay in the *status quo*. However, harmonization may be obtained with the help of financial transfers. These monetary transfers can be operated between coalitions: a coalition who benefits from the harmonization compensates the other coalition for its losses. This type of transfers will be called **external transfers**. The transfers can be also carried out between country members of a coalition. Such a coalition accepts the harmonization at the aggregate level (to respect the aggregate surplus criteria of all members) but some of its members lose from the harmonization process. In this case, the “winning” countries (that are either in the category of the producing or of the non-producing countries) can compensate the countries of the other category for their losses. This type of transfers will be called **internal transfers**.

We distinguish three criteria of feasibility of the harmonization:

**Criteria 1** : a “first best harmonization” happens when (i) the two coalitions  $E_1, E_2$  accept the harmonization without receiving external compensatory transfers and (ii) all the countries of the two coalitions have a better profit compared to the status quo (without internal transfers). Such a harmonization is **fully** stable.

**Criteria 2** : a “second best harmonisation” happens when (i) the two coalitions  $E_1, E_2$  accept the harmonization without receiving external compensatory transfers and (ii) some countries (belonging to one of the two coalitions) lose compared to the status quo but can be compensated by internal transfers. Such a harmonization is **partly** stable.

**Criteria 3** : a « third best harmonisation » happens when a coalition refuses the harmonization but can be compensated by an external transfer. Such a harmonization is **loosely** stable.

It is clear that in a third best harmonization, one of the coalitions, *e.g.*  $E_1$ , benefits from the harmonization while the other coalition  $E_2$  loses from it. If such a harmonization is implemented, then one can find external transfers from  $E_1$  to  $E_2$  that (i) are sufficient to compensate the countries in  $E_2$  that lose from harmonization for their losses; (ii) do not make countries of  $E_1$  worse off than in the *status quo*. Thus, all countries profit from the harmonization.



#### 4. FISCAL HARMONIZATION WITH HOMOGENOUS COUNTRIES

We begin with the simple case of identical countries (in the remainder of this paper, we will refer to this case as the “homogeneity case”): all countries are “producing” countries. The *status quo* consists in a Nash-Equilibrium between two coalitions whose sizes respectively are  $N_c$  and  $N-N_c$ .

##### *Environmental outcome*

As harmonization’s implementation is partly motivated by the will to improve the environment, it is important to analyse its effects on the environment. **For low values of the marginal environmental costs, harmonization is less environmental friendly than the *status quo*.**

Indeed, environmental costs are higher in the *status quo* than if harmonization takes place as soon as  $s > s_0 = \frac{2a}{N(2+N)}$ . This result is independent of the sizes of the *ex ante* coalitions in the *status quo*.

Thus, harmonization has not systematically the desirable effects in terms of environmental policy: because the governments take into account different economic interests, economic considerations may have more impact than the environmental objectives. Indeed, when environmental costs are low, the harmonization translates into an indirect subsidy to consumption and production of the good: the tax product does not compensate environmental losses, so that adaptation costs can never be paid for; governments use these budget deficits to give indirect subsidies to fuel consumption.

This effect does also take place in the *status quo*, although not with the same magnitude, because the government of country  $i$  in one coalition have no interest into giving (indirect) subsidies to a producer of the other coalition that also sells its production to consumers of country  $i$ . However, when the level of environmental costs gets higher, the negative effect of production strongly impacts the welfare criterions. Through harmonization, the governments dampen this effect by reducing the aggregate supply and consumption.

##### *Harmonization stability*

In the homogeneity case, by definition, harmonization is fully stable if and only if it is also partly stable: since all countries are identical, intra-coalition transfers do not allow any compensation to happen. Thus, in this section, we only need to investigate full and loose stability of harmonisation.

We begin with the more demanding concept of stability: **whatever the environmental costs, the harmonization is not fully stable with respect to small *ex ante* coalitions.** Thus, if one of the coalitions is too small, the first best harmonization never occurs.

Indeed, whatever the environmental costs are, a small *ex ante* coalition always has an incentive to refuse the harmonization. More precisely, for a given  $N$ , there is one (and only one)  $N_c$  such that coalitions  $E$  whose size is less than  $N_c$  prefer the *status quo* to the harmonization.  $N_c$  does not depend on the value of  $s$ . This coalition can be seen as a free-rider, since it profits from the efforts of the other (big) coalition.

What we call here “small coalitions” can be analytically derived:

$$N_c = \frac{1}{4} \left[ N^{3/2} \sqrt{8+9N} - 3N^2 \right]$$

Thus,  $N_c/N$  goes asymptotically towards  $1/3$  as  $N$  increases. Our results comfort the “small coalition” thesis we mentioned in introduction (Pereau & Tazdaït, 2001): as soon as four countries or more are concerned by climate change negotiations, the stability of international agreements is threatened by free-riding behaviours.

The countries willing to implement harmonization, however, might accept to transfer a part of their gains from harmonization to a coalition that would otherwise be reluctant to implement the harmonization. If these gains are high enough, the small coalition would have an incentive to reach an agreement with the big coalition: **harmonization induces sufficient gains so as to be preserved by financial transfers less important than those gains.**

In other words, the benefits of harmonization, compared with those of a Nash-Equilibrium between two *ex ante* coalitions, are always strong. Thus, **harmonization is always loosely stable in the homogeneity case**, and the third best harmonization may be implemented in all cases.

As a consequence, there is a possibility for a “voluntary coalition” to preserve the stability of harmonization, by compensating economic losses of a small coalition. Meanwhile, this voluntary coalition is still better off if harmonization takes place than in the *status quo*. As a conclusion, if a great number of countries are decided to implement an international agreement, harmonization at the global level can take place.<sup>9</sup>

#### *Strategical aspects of environmental costs*

These results on the stability of harmonization are not influenced by the value of environmental marginal damages. As a consequence, one may think that uncertainties on the magnitude of the future climate change should not influence the decision to harmonize fuel taxes, at least if all countries were identical. However, the tax levels, the magnitude of the gains from harmonization, and thus of the financial transfers that could be demanded by a deviating coalition, do depend on the value of  $s$ . For a given estimation of the value of  $s$ , if  $s > s_0$  (resp.  $s < s_0$ ), then producers sell more (resp. less) in the *status quo* than in the harmonization. Thus, if the common estimation of  $s$  is higher than this threshold value, they have an interest into maintaining the *status quo*.

On the one hand, governments of the small coalition have an incentive to try to convince other countries that environmental costs are high, so as to get important financial compensations. However, the tax level they will set, and thus their welfare, are linked to the value of  $s$  on which agreements are based. The higher this value is, the higher will be the tax level, and the lower will be the consumers’ surplus and the profit of the producer. In fact, for a given “real”  $s$  value, there is an optimal  $s' > s$  on which governments of the small coalition wish to base the negotiations.

On the other hand, the lower the value of  $s$  on which agreements are based, the higher the profits of producers will be. Thus, producers of all countries may be willing to convince other actors that environmental costs are low. Furthermore, they will be interested into preventing

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<sup>9</sup> International agreements can be conceived so as to warrant to members that a critical mass is reached. The Kyoto Protocol for instance has been ratified by countries at different times. One of its article mentioned that it would be implemented only if 55% of the countries who signed the Protocol (signature was a step before ratification) representing 55 % of GES emissions throughout the world, would indeed ratify this protocole. This critical mass was reached, but no integral agreements have been implemented (i.e. some countries did not ratify the Protocole).

the harmonization process from taking place, for instance by magnifying uncertainties on the value of  $s$ <sup>10</sup>.

## 5. FISCAL HARMONIZATION WITH HETEROGENOUS COUNTRIES

We now examine the situation where  $P < N$ , and evaluate if heterogeneity is likely to enhance or to undermine the harmonization process. If countries are heterogeneous with respect to the existence or the absence of a domestic producer, their interests can diverge radically. Thus, the size of the *ex ante* coalitions in the *status quo* is not the only parameter that we need to take into account.

Indeed, this section demonstrates that composition matters. More precisely, **the ratio of producing countries to non-producing countries in a coalition will influence the outcome of negotiations at the global level.**

### *Notations*

In this section, we need to explicit the composition of the two *ex ante* coalition  $E_1$  and  $E_2$ . The former is composed of  $n_1$  non-producing countries, and  $n_2$  producing countries. Meanwhile,  $E_2$  is composed of  $n_3$  non-producing countries, and  $n_4$  producing countries.

Thus,  $P = n_2 + n_4$ , and  $N = n_1 + n_2 + n_3 + n_4$ .

As we have two more variables (namely  $P$  and  $n_1$ ) than in the homogeneity case, general results are analytically tractable but difficult to exploit extensively. Thus, we turn to numerical simulations to make our point, and focus our analysis on a case where:

- *ex-ante* coalition are of the same size:  $n_1 + n_2 = n_3 + n_4 = N/2$ ,
- Half of the countries are producing countries:  $P = N/2$ .

In the homogeneity case, two *ex ante* coalitions of the same size both had incentives to implement the harmonization process. In this situation, harmonization was fully stable.

In our numerical simulations, we took  $N = 50$ . Thus,  $P = 25$ , and  $n_1$  varies from 0 to 25. We restricted our investigations to the cases where taxes and traded quantities are positive, which implies that  $s > 0.15$ .

If  $n_1$  is zero, or close to zero, we call  $E_1$  a producing coalition, and  $E_2$  a non-producing coalition. Furthermore, we say that  $E_1$  and  $E_2$  are **complementary**. Meanwhile, if  $n_1$  is closer to a medium value, we will say that *ex ante* coalitions are **balanced**.

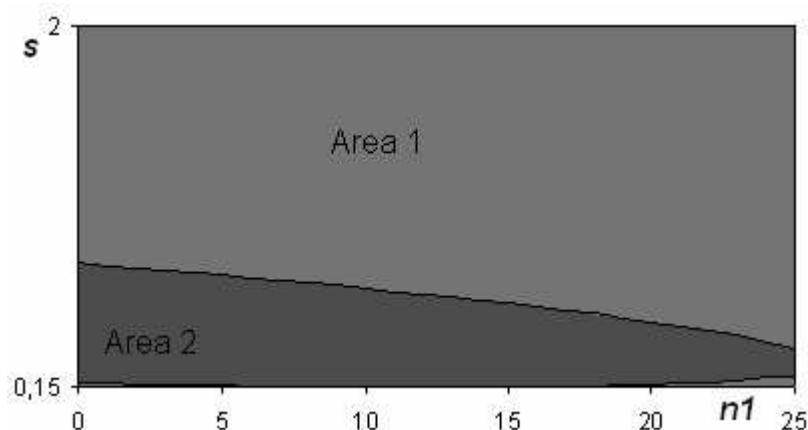
### *Full stability*

Figure 1 shows the impacts of harmonization on countries of coalition  $E_1$ , depending on the value of  $n_1$ , and on the magnitude of environmental costs. It is noteworthy that, in the particular case we examine, one can also see on this figure the impacts on countries of coalition  $E_2$  as well. This is obtained by an axial symmetry in respect to a central vertical axis. This is so because  $n_3 = 25 - n_1$ .

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<sup>10</sup> As a matter of fact, there have been firms that have been denying the likeliness of climate change, or that have been claiming that global change impacts would not be important.

For high values of the marginal environmental cost, harmonization is fully stable. Exactly as in the homogeneity case, when countries are confronted with high environmental damages ( $s > 0.75$  in Fig. 1), harmonization induces a better outcome for all of them. The harmonized tax level is very high compared to those of the coalitions in the *status quo*. The losses of the producers are compensated by the decrease of environmental damages.



**Figure 1:** area 1 corresponds to the values of  $(n1, s)$  for which harmonization is fully stable; area 2 corresponds to the cases where producing countries of coalition  $E_1$  have no interest into harmonization.

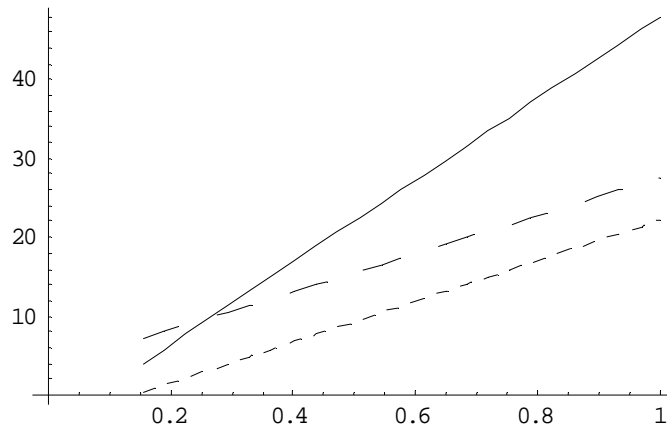
For medium marginal environmental costs ( $0.165 < s < 0.75$  in Fig.1), the harmonization process is detrimental to the producing countries of a producing coalition ( $n1$  close to zero). Thus, for medium environmental costs, the producing countries of a producing coalition prevent the harmonization from being fully stable<sup>11</sup>.

Area 2 is broader for small values of  $n1$ , and there is a continuous evolution of the frontier fully stable / not fully stable with respect to  $n1$ : for a given value of  $s$ , the less producing countries there are in an *ex ante* coalition, the more incentive this coalition has to the implementation of harmonization.

The reason is that the more producing countries there are in a coalition, the more the interest of producers will influence the tax level in the *status quo*. Thus, the lower will be the tax level of a producing coalition if no harmonization takes place. If, in addition,  $s$  is low, then the profits of the firms and consumers surplus compensate for the environmental costs caused by a low tax level.

Of course, if there are only few producing countries in coalition  $E_1$ , they have almost no influence on the tax level. In this case, the tax level in  $E_1$  is even greater than the harmonized tax level. However, the producing countries still prefer the *status quo*:  $E_2$  is a producing coalition and the tax level in  $E_2$  is very low (see Fig. 2). Thus, producers of  $E_1$  will be given the opportunity to sell their production in  $E_2$ . As a consequence, whatever the composition of the *ex ante* coalitions, all the producing countries prefer the *status quo* to the harmonization for intermediary values of  $s$  ( $0.2 < s < 0.35$ ).

<sup>11</sup> In all this section, only producing countries' interests weaken the stability of harmonization. This is only so because we restricted ourselves to the study of positive tax levels. If subsidies are authorized, then for low values of  $s$ , non-producing countries may prefer the *status quo* to the harmonization.



**Figure 2:** tax levels w.r.t. the values of  $s$ , for complementary coalitions ( $nI = 24$ ). The full line is the harmonized tax level, the dashed (resp. dotted) line is the tax level in coalition  $E_1$  (resp.  $E_2$ ).

However, for lower values of  $s$  ( $s < 0.164$ ), the producing countries in a producing coalition are better off with harmonization than in the *status quo*. The tax levels of the complementary (non-producing) coalition are still relatively high (see Fig. 2), at least they are higher than the harmonized tax level. At the social optimum, environmental costs are compensated by producers' profits, and harmonization allows producers to sell more in all countries, including countries from  $E_2$ <sup>12</sup>. Thus, for very low values of  $s$ , and for complementary coalitions, harmonization is fully stable.

This does not happen for balanced *ex ante* coalitions: if producing countries are more evenly scattered in  $E_1$  and  $E_2$ , producers benefit from fiscal competition; coalitions do not internalize the environmental damages that they induce for the other coalition, and set tax levels lower than the harmonized tax level.

#### *Internal and external financial transfers*

Of course, the possibility of financial transfers between countries of the same coalition improves the likeliness of stability of harmonization. And it might be the case that the gains that non-producing countries get from harmonization can compensate for the losses of producing countries. Figure 2 shows that if  $s$  is low, harmonization is partly stable for balanced *ex ante* coalitions. Indeed, if non-producing countries are numerous (high  $nI$ ), their gains from harmonization are higher than the losses of the producing countries.

However, this is not the case in a producing coalition. As a result, for low values of  $s$ , harmonization is not partly stable for complementary coalitions: these coalitions are faced with the strong heterogeneity of their members, and cannot reach a consensus so as to leave the *status quo*.

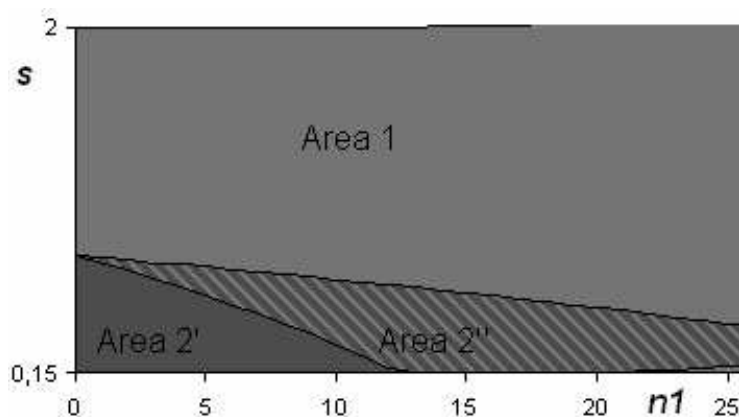
While in the homogeneity case only the sizes of the coalitions mattered for the stability of harmonization, taking into account heterogeneity implies that:

- (i) The composition of the *ex ante* coalitions, *i.e.* the ratio of producing to non-producing countries in the coalitions, is crucial for the stability of harmonization.

<sup>12</sup> However, the environmental output of harmonization is still better than the one of the *status quo*. This result changes if negative tax levels (subsidies) are considered for low values of  $s$ , that we did not include in our investigation. In this case, the environmental friendliness of harmonization compared to *status quo* depends also on the composition of the coalitions: balanced coalitions lead to higher aggregate consumption levels.

Diverging interests inside each coalition can prevent a general agreement from being reached.

- (ii) Harmonization's stability is also dependant on the level of environmental costs, which can exacerbate or reduce the opposition between producing and non-producing countries in a coalition.



**Figure 3:** this figure is the same as figure 1, except for area 2, which has been divided into area 2' and area 2''. The latter corresponds to values of  $(n1, s)$  for which  $E_1$  gains from harmonization.

To conclude this section, we investigate loose stability. If we stick to the numerical case explored so far, if financial transfers between coalitions are authorized, the harmonization can be stabilized. Therefore, for these *ex ante* coalitions, whatever the value of  $s$ , harmonization is loosely stable.

However, a numerical exploration of other configurations shows that loose stability can be impossible to reach,

- if  $P$  is very little compared to  $N$ ;
- if one of the coalition is very small compared to the other<sup>13</sup>.

Thus, strong asymmetries in size or in composition of *ex ante* coalitions lead to loosely unstable harmonization. Again, in these cases, the producing countries have a strong incentive to refuse the implementation of harmonization. These configurations give them little weight in harmonization, and much more in their *status quo* coalition.

## 6. CONCLUSION

The Kyoto Protocol has been ratified by 161 countries; negotiations extend to other countries as well at the so-called Conferences Of the Parties, occurring once a year. Because they have common interests relative to the Climate Change process, or to other policy fields, most countries are grouped in coalitions. As a matter of fact, negotiation process rapidly became a discussion between several groups more or less solid:

- The 25 EU members meet in private to agree on common positions.
- Some of the other developed countries form the Umbrella Group.
- 77 developing countries use the G-77 to establish a common position (G-77 was founded in 1964, more than thirty years before the Kyoto Protocol).
- Some of those developing countries also belong to the Alliance of Small Island States.

<sup>13</sup> According to numerical explorations, there seems to be a treshold situated around  $e_1 = N/3$ .

- More recently, the Asian-Pacific Partnership on Clean Development and Climate had its first meeting in year 2006, and includes Australia, China, India, Japan, Republic of Korea as well as the USA.

Those coalitions behave in a non-cooperative manner with respect to each other: USA refused to go on with the Kyoto Protocol, considering the process would be unfair as long as developing countries did not take any binding commitments. Meanwhile, those coalitions implement domestic policies in a more cooperative manner. For instance the EU behaves as a single party to the Kyoto Protocol, and shares its aggregate burden between its members so as to maximize its welfare; the Asian-Pacific Partnership committed to a separate emission mitigation process.

This paper sheds some light on the interactions of those coalitions. It demonstrates that in a game confronting two coalitions with the possibility of fiscal harmonization, heterogeneity between countries can induce strong instabilities for the harmonization process. These instabilities are related to the international profits of domestic firms, whose interests influence the outcome of negotiations. Two different threats against harmonization can be distinguished:

- (i) At the aggregate level, a coalition may have an incentive to stay in the status quo, and prevents the harmonization process from happening. The producing countries which are members of this coalition profit from the tax levels that are lower than the harmonized tax in one or two of the coalitions. In this case, at the coalition level, the gains of producers outweigh the losses of consumers and the impacts of global environmental change.
- (ii) Even if a coalition has an incentive to implement harmonization, it may be the case that some of its members (more precisely its producing countries) would lose from this process. The mechanism is the same as in case (i) above, only this time the gains of producing countries from the *status quo* are not greater than the losses of non-producing countries.

Briefly stated, both sizes and compositions (w.r.t. the number of producing countries) of the *ex ante* coalitions matter for the stability of the harmonization agreements. Furthermore, the stability of a coalition structure also depends on the level of environmental costs. Thus, knowledge or beliefs on environmental damages may be strategically used by economic agents.

Stability is in fact a general problem in climate change negotiations, which has been illustrated in the history of mitigation agreements by the case of the USA withdrawing from the Protocol before it was implemented. Nevertheless, the European Union took an important step forward with the implementation in year 2005 of an Emissions Trading Scheme concerning six energy-intensive sectors. The EU has also implemented fiscal harmonization to mitigate emissions originating from the transportation sector.

However, the most important challenge is beyond the European frontiers: will EU be able to convince another coalition (namely developing countries or Asian-Pacific Partnership) to join its mitigation efforts? In this coalition game, our results suggest that the repartition of fossil reserves among countries may be a serious obstacle to harmonization: unless environmental costs are very high, countries with important reserves will prefer to stay in the *status quo*.

### *Insights for future research*

Our framework sheds some light on the role of heterogeneity in the climate change negotiations. However, it lacks several characteristics of the real world, and taking them into account can be considered as a research agenda.

First, we assumed that countries present in the negotiation process reached a consensus on the value of  $s$ . The outcome of negotiations depends on this value, and in some cases financial transfers cannot be considered as a solution to ensure the stability of harmonization. But even when such a solution can be found, we did not investigate the possibility of a strategic use of uncertainties on  $s$  by actors. For instance in the homogeneity case, if  $s > s_0$ , then the higher the beliefs on  $s$  are, the higher are the transfers the little coalition may claim. In a situation of deep uncertainty as is the case in the climate change case, reaching an agreement over these transfers may be difficult

Besides, even if there were no controversy on the value of adaptation costs, unpopularity of financial transfers directed towards other countries is a big obstacle. Such unpopularity happens even if the targets of the transfers are developing countries, at least for those who already experience strong economic growth (e.g. China and India). Of course such a solution is even more difficult to accept when transfers are designed to compensate the losses of rich (producing) countries.

Second, we assumed that adaptation costs were the same for all countries. Though the estimations of climate models are deeply uncertain at the sub-continental level, there is no doubt that those costs will not be the same for all countries throughout the world. Thus, these costs will be balanced with industrial interests of domestic firms differently in each country, and influence the position of national governments.

Third, we assumed that the negotiation process concerned *ex ante* coalitions. However, endogenous coalition formation theory is best fitted to the description of the emergence of coalitions in the real world. For instance, it is certainly no coincidence that so many members of the Asian-Pacific Partnership have so important coal reserves. Third, we assumed that all countries were included in two coalitions, which decided to implement carbon taxes. There are of course more than two coalitions that participate to the climate change negotiations: the interaction of USA and developing countries commitments illustrates that this multiplicity also impacts the outcome of the negotiations.

In all of these possible extensions, it is most likely that international interests of national firms will still influence the negotiations outcome. The exact role of heterogeneities in those frameworks, therefore, is still an open question.

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