Climate Clubs, Border Carbon Adjustments and Trade Wars

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Introduction

▶ The idea of creating a climate club for overcoming free-riding in international climate policy has become very popular since the publication of Nordhaus' (2015) paper.

↦ The club is an agreement by participating countries to undertake harmonized emissions reductions (IEA/Climate Treaty).

i) International target carbon price (prices vs quantities).
ii) Penalization: an uniform percentage tariffs on the imports of non-participating into the club region (trade sanctions).

↦ Coalition_DICE model (15 regions): as the target carbon price rises, it becomes increasingly difficult to attain the cooperative equilibrium (a global climate club) using trade sanctions.

▶ On 14th July 2021, the EC adopted a proposal for a new CBAM which will put a carbon price on imports of a targeted selection of products. The Commission's proposal for a CBAM should prevent the risk of *carbon leakage* and support the EU's increased ambition on climate mitigation, while ensuring WTO compatibility.

▶ The Economist (leaders), Jul 17th 2021, "Carbon border taxes are defensible but bring great risks. The EU's proposal may set off another trade war."

- International organizations/agencies have an important role in international negotiations, but are the countries that finally negotiate and ratify or not the agreements.
- In this paper, we consider a different approach assuming that international organizations/agencies (IA) can play a more active role in international negotiations. We assume that the IA can present a proposal of cooperation and invite all countries to adhere to the proposal. Thus, countries would sign an **adhesion treaty** that gives access to a climate club designed by an IA.
- The proposal will consist of a harmonized carbon tax and the application of a CBAM to penalize non-members selected with the aims of overcoming free-riding in international climate policy and achieve full participation.
- Thus, we analyze an extension of the standard coalition formation game that incorporates a new player, the IA, and a stage zero where the IA announces its proposal and invites all countries to join it, and consider two scenarios, one without retaliation by non-members and another with retaliation.

- The exercise we develop consists of giving the maximum legally enforcement power to the club members and explore if there exists a carbon tax for which the grand coalition is stable.

- Notice that if the policy is announced before countries decide on participation, the stability conditions will depend on the club tax. Then, we assume that in stage zero, the IA chooses the club tax that maximizes *global social welfare* among the taxes that eliminate the incentives to deviate unilaterally from the global climate club.

- The aim of this paper is to investigate if this problem has a solution, characterize their properties and find out how this solution changes if non-signatories charge a tariff on signatories' exports.

- Main conclusions:

1. Without retaliation, there exists one and only one carbon tax for which the grand coalition is stable regardless of the degree of product differentiation.
2. In the equilibrium no BCAs are applied.
3. The first-best carbon tax does not make stable the grand coalition.
4. With retaliation, no carbon tax can stabilize the grand coalition regardless of the degree of product differentiation.

Literature review

- Strategic trade models:

i) Anoulies (2014) and Eyland and Zaccour (2012, 2014). Two-country models.

ii) Barrett (1997), Helm and Schmidt (2015), Kuhn et al. (2019), Al Khourdajie and Finus (2020) and Diamantoudi *et al.* (2020).

- Competitive trade models: Eichner and Pethig (2013,2014).

- Experimental economics: Barrett and Dannenberg (2021).

- CGE models: Lessmann *et al.* (2009), Böhringer *et al.* (2016) and Hagen and Schneider (2021) and Nordhaus (2021).

https://ec.europa.es/taxation_customs/green-taxation-0/carbon-border-adjustment-mechanism_en

The model

▶ We use an intra-industry trade model with *n ex-ante* symmetric countries and a representative firm and consumer in each country.

▶ Firms produce a horizontally differentiated good whose output releases greenhouse gases which cause environmental damages.

▶ Firms compete in quantities in segmented markets.

▶ There are no transport costs and before the creation of the climate club the status quo is a free trade regime.

▶ We analyze a four-stage game:

- **Stage zero**: an International Agency (IA) proposes the creation of a climate club to adopt an harmonized carbon tax, t_i, and charge a BCA rate equal to one to imports coming from non-member countries that apply a lower tax or no tax.
- **Stage one:** all countries decide simultaneously and non-cooperatively whether to enter the climate club.

- **Stage two:** members adopt the carbon tax and the BCA proposed by the IA, whereas non-members select the carbon tax that maximizes their national welfare taking as given membership and the policy followed by the rest of countries (no retaliation).
- **Stage three:** all firms choose simultaneously and non-cooperatively their segmented market outputs for each of the n markets by maximizing their net benefits.

▶ The game is solved by backward induction.

Stage three: production, trade and consumption

▶ Al Khourdajie and Finus (2020).

▶ The inverse demand function in country i for the variety produced in country k is expressed as

$$p_{ik} = a - (1-\gamma)q_{ik} - \gamma Q_{i.}, \quad a > 0, \quad \gamma \in [0,1]. \tag{1}$$

$$Q_{i.} = \sum_{k \in N} q_{ik} \;=\; \text{total consumption.}$$

$\gamma = 1$: all firms produce an homogeneous good
$\gamma \in (0,1)$: we have an oligopoly with product differentiation in each country.
$\gamma = 0$: firms act like a monopolist for their variety in the market.

- We denote the set of members by $S \subseteq N$ with m the cardinality of S and $m \in [2, N]$.
- A representative member will be designed by $i(k)$ and a representative non-member by $j(l)$.
- Net profits for a firm located in a member country i is given by

$$\pi_i = \sum_{k \in S} \pi_{ki} + \sum_{l \notin S} \pi_{li} = \sum_{k \in S} q_{ki}(p_{ki} - c - t_i) + \sum_{l \notin S} q_{li}(p_{li} - c - t_i). \tag{2}$$

- Net profits for a firm located in a non-member country j is

$$\pi_j = \sum_{k \in S} \pi_{kj} + \sum_{l \notin S} \pi_{lj} = \sum_{k \in S} q_{kj}(p_{kj} - c - t_j - \Omega) + \sum_{l \notin S} q_{lj}(p_{lj} - c - t_j) \tag{3}$$

where

$$\Omega = \begin{cases} \phi(t_i - t_j) & if \;\; t_i \geq t_j \\ 0 & if \;\; t_i \leq t_j \end{cases}, \quad \phi \in [0, 1], \tag{4}$$

and c stands for the marginal cost of production.

- Notice that $\phi = 1$ represents the “maximum legally possible enforcement power” for the club members.

Non-member markets

- Firm i's variety produced in a member country exported to a non-member l's market:

$$q_{li} = \frac{\alpha(2-\gamma) - (2-\gamma+\gamma(n-m))t_i + \gamma\sum_{j\notin S} t_j}{((n-1)\gamma+2)(2-\gamma)}, \quad (5)$$

$$\frac{\partial q_{li}}{\partial t_i} < 0, \ \frac{\partial q_{li}}{\partial t_j} > 0.$$

- Firm j's variety produced in a non-member country exported to a non-member l's market:

$$q_{lj} = \frac{\alpha(2-\gamma) + \gamma m t_i - ((n-2)\gamma+2)t_j + \gamma\sum_{r\notin S; r\neq j} t_r}{((n-1)\gamma+2)(2-\gamma)}, \quad (6)$$

$$\frac{\partial q_{lj}}{\partial t_i} > 0, \ \frac{\partial q_{lj}}{\partial t_j} < 0, \ \frac{\partial q_{lj}}{\partial t_r} > 0.$$

- BCAs do not affect the trade to non-member markets.

Member markets

- Firm i's variety produced in a member country exported to a member k's market:

$$q_{ki} = \frac{\alpha(2-\gamma) + \gamma(1-\phi)\sum_{j\notin S} t_j - (2-\gamma+\gamma(n-m)(1-\phi))t_i}{((n-1)\gamma+2)(2-\gamma)}, \tag{7}$$

$$\frac{\partial q_{ki}}{\partial t_j} > 0, \ \frac{\partial q_{ki}}{\partial t_i} < 0, \ \frac{\partial q_{ki}}{\partial \phi} = \gamma \frac{(n-m)t_i - \sum_{j\notin S} t_j}{((n-1)\gamma+2)(2-\gamma)} > 0, \text{ if } t_i > t_j, \ \forall j.$$

- Firm j's variety produced in a non-member country exported to a member k's market:

$$q_{kj} = \frac{\alpha(2-\gamma) + (\gamma m - \phi(2+\gamma(m-1)))t_i}{((n-1)\gamma+2)(2-\gamma)} - \frac{(1-\phi)((n-2)\gamma+2)t_j - \gamma(1-\phi)\sum_{l\notin S; l\neq j} t_l}{((n-1)\gamma+2)(2-\gamma)}. \tag{8}$$

$$\frac{\partial q_{kj}}{\partial t_i} =?, \ \ \frac{\partial q_{kj}}{\partial t_j} < 0, \ \frac{\partial q_{kj}}{\partial t_l} > 0, \ \frac{\partial q_{kj}}{\partial \phi} = \frac{(2+\gamma(m-1))(t_i - t_j)}{((n-1)\gamma+2)(2-\gamma)} < 0, \text{ if } t_i > t_j.$$

- Notice that if $\phi = 1$

$$q_{ki} = q_{kj} = \frac{a - c - t_i}{(n-1)\gamma + 2}. \tag{9}$$

- Trade to member markets does not depend on the carbon tax applied in non-member countries.

- We focus on the stability of the grand coalition $(m = n)$ when $\phi = 1$.

Stage two: non-members' carbon tax

$$\max_{t_j} W_j(n-1, t_i, t_j) = \underbrace{\frac{\gamma}{2} Q_{j.}^2 + \frac{1-\gamma}{2} \sum_{k \in N} q_{jk}^2}_{\mathrm{CS}_j}$$

$$+ \underbrace{\sum_{k \in S} q_{kj}(p_{kj} - c - (t_i - t_j))}_{\mathrm{PS}_{kj}} + \underbrace{q_{jj}(p_{jj} - c)}_{\mathrm{PS}_{jj}} - \underbrace{\delta Q}_{\mathrm{D}_j}. \tag{10}$$

- In order to facilitate the presentation we have selected the case of *homogeneous goods* ($\gamma = 1$), although the results obtained for this case when there is no retaliation applied for all $\gamma \in [0, 1]$.

- Non-members' welfare function

$$\max_{t_j} \; W_j(n-1, t_i, t_j) = \underbrace{\frac{1}{2} Q_{j.}^2}_{\text{CS}_j} + \underbrace{\sum_{k \in S} q_{kj}(\alpha - Q_{k.} - (t_i - t_j))}_{\text{PS}_{kj}} + \underbrace{q_{jj}(\alpha - Q_{j.})}_{\text{PS}_{jj}} - \underbrace{\delta Q}_{\text{D}_j},$$

where $\alpha = a - c$.

- Non-members' reaction function

$$t_j = \frac{n\,(n-2)\,\alpha + (n+1)\delta - (2n-1)\,(n-1)\,t_i}{2n-1}. \quad (11)$$

Remark 1 *t_j is a strategic substitute of t_i.*

- Non-members' welfare function ($m = n - 1$)

$$W_j(n-1, t_i) = \frac{f_0(n){t_i}^2 + f_1(n, \alpha, \delta) t_i + f_2(n, \alpha, \delta)}{2(2n-1)(n+1)^2}, \quad (12)$$

▶ Constraints on the carbon tax

$$t_i - t_j = t_i - \frac{n\alpha\,(n-2) + (n+1)\delta - (2n-1)\,(n-1)\,t_i}{2n-1} \geq 0,$$

$$t_i \geq \underline{t_i^h} = \frac{n(n-2)\alpha + (n+1)\delta}{(2n-1)n}. \tag{13}$$

– Non-negativity constraints

$$q_{ik}(n-1, t_i) \geq 0,\ \ q_{ij}(n-1, t_i) \geq 0 \Leftrightarrow t_i \leq \alpha. \tag{14}$$

$$q_{ji}(n-1, t_i) \geq 0 \Leftrightarrow t_i \leq \overline{t_i^h} = \frac{(n^2-1)\alpha + (n+1)\delta}{(2n-1)(n+1)}. \tag{15}$$

$$q_{jj}(n-1, t_i) \geq 0 \Leftrightarrow t_i \geq \tilde{t}_i^h = \frac{(n^3-2n^2-2n+1)\alpha + n(n+1)\delta}{(2n-1)(n-1)(n+1)}. \tag{16}$$

Remark 2 *The ordering is*

$$\tilde{t}_i^h < \underline{t_i^h} < \overline{t_i^h} < \alpha,$$

provided that $\delta < n\alpha$.

▶ We assume throughout the paper that $n\delta < \alpha$ that is a condition that guarantees that output is positive for the efficient outcome.

Stage-one: the stability of the grand coalition

- The stability function for $m = n$

$$S(n, t_i) = W_i(n, t_i) - W_j(n-1, t_i).$$

- Members' welfare function

$$W_i(n, t_i) = \underbrace{\frac{1}{2} Q_{i.}^2}_{\mathrm{CS}_i} + \underbrace{\sum_{k \in N} q_{ki}(\alpha - Q_{k.})}_{\mathrm{PS}_{ki}} - \underbrace{\delta Q}_{\mathrm{D}_i},$$

$$W_i(n, t_i) = \frac{n(\alpha - t_i)}{2(n+1)^2}(nt_i + (n+2)\alpha - 2n(n+1)\delta). \tag{17}$$

- $q_{ki}(n, t_i) \geq 0 \Leftrightarrow t_i \leq \alpha.$

- Thus, if $\delta < \alpha n$ then there exists an interval for the carbon tax $[\underline{t_i^h}, \overline{t_i^h}]$ such that if the club tax belongs to the interval all quantities that are used for calculating the stability function are non-negative and $t_i \geq t_j(n-1)$.

- The stability function for $m = n$

$$S(n, t_i) = -\frac{n^2(2n-1)^2 t_i^2 - 2n(2n-1)\varphi(n,\alpha,\delta) t_i + \varphi(n,\alpha,\delta)^2}{2(n+1)^2(2n-1)}, \tag{18}$$

$$\varphi(n) = n(n-2)\alpha + (n+1)\delta. \tag{19}$$

Remark 3 *The stability function is strictly concave with respect to* t_i.

- $S(n, t_i) = 0$ defines the set of carbon taxes for which the grand coalition is stable.

Stage-zero: a second-best carbon tax

The IA select among the taxes that make the grand coalition stable the one that maximizes global welfare.

$$\max_{t_i} \sum_{i \in N} W_i(n, t_i)$$

$$s.t. \; S(n, t_i) \geq 0, \quad t_i \in [\underline{t_i^h}, \overline{t_i^h}].$$

Proposition (1)

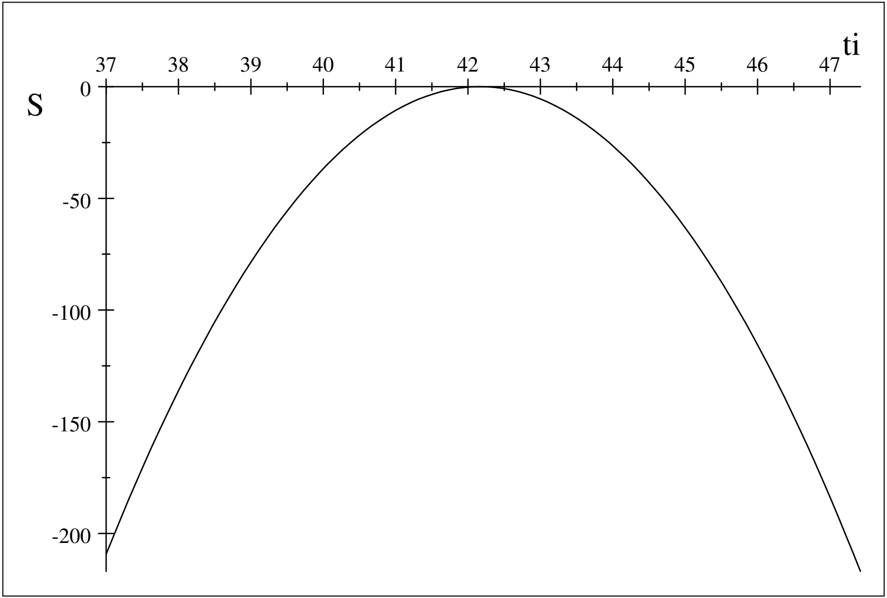
The carbon tax selected by the IA is $\underline{t_i^h}$

Proof

$$\left.\frac{\partial S(n, t_i)}{\partial t_i}\right|_{\underline{t_i^h}} = S(n, t_i)|_{\underline{t_i^h}} = 0$$

Then the strict concavity of $S(n, t_i)$ implies that $S(n, t_i) < 0$ for all $t_i \in (\underline{t_i^h}, \overline{t_i^h}]$.□

- The choice set contains only one tax.
- Notice that if a country decides not to enter the club, its optimal tax is $\underline{t_i^h}$ and consequently no BCAs will be applied to that country' exports.
- The IA uses its strategic advantage to induce the non-member country to select the same tax that the one proposed by the IA and that is enough to eliminate the incentives to deviate from the grand coalition.



α=100, n=10, δ=1, $\underline{t_i^h}$=42.16, $\overline{t_i^h}$=47.42

The first-best carbon tax

$$\max_{t_i} \sum_{i \in N} W_i(n, t)$$
$$s.t. \quad t_i \leq \alpha.$$

$$t_i^* = \frac{n(n+1)\delta - \alpha}{n}. \tag{20}$$

Proposition (2)

The first-best carbon tax is lower than the global marginal damages defined by $n\delta$.

- Notice that as firms have market power the tax corrects two market failures: a negative externality and the distortion created by firms' market power.

Proposition (3)

The tax selected by the IA can be higher or lower than the first-best carbon tax depending of the severity of marginal damages.

- The club tax can promote full participation, but it does not implement the efficient outcome.

Retaliation

- **Stage two:** members adopt the carbon tax and the BCA proposed by the IA, whereas non-members select the carbon tax and tariff on members' imports that maximizes their national welfare taking as given membership and the policy followed by the rest of countries (retaliation).

Stage three: production, trade and consumption

- Net profits for a firm located in a member country i is given by

$$\pi_i = \sum_{k \in S} q_{ki}(p_{ki} - c - t_i) + \sum_{l \notin S} q_{li}(p_{li} - c - t_i - \tau_l), \tag{21}$$

where τ_l is the tariff adopted by non-member country l.

Non-member markets

- Firm i's variety produced in a member country exported to a non-member l's market:

$$q_{li} = \frac{\alpha(2-\gamma) - (2-\gamma+\gamma(n-m))(t_i + \tau_l) + \gamma \sum_{j \notin S} t_j}{((n-1)\gamma + 2)(2-\gamma)}, \qquad \frac{\partial q_{li}}{\partial \tau_l} < 0 \tag{22}$$

▶ Firm j's variety produced in a non-member country exported to a non-member l's market:

$$q_{lj} = \frac{\alpha(2-\gamma) + \gamma m(t_i + \tau_l) - ((n-2)\gamma + 2)t_j + \gamma \sum_{r \notin S; r \neq j} t_r}{((n-1)\gamma + 2)(2-\gamma)}, \quad \frac{\partial q_{lj}}{\partial \tau_l} > 0. \qquad (23)$$

Stage two: non-members' policy

▶ Non-members' welfare function ($\gamma = 1$)

$$\max_{t_j, \tau_j} W_j(n-1, t_i, t_j, \tau_j) = \underbrace{\frac{1}{2} Q_{j.}^2}_{\text{CS}_j} + \underbrace{\sum_{k \in S} q_{kj}(\alpha - Q_{k.} - (t_i - t_j))}_{\text{PS}_{kj}}$$

$$+ \underbrace{q_{jj}(\alpha - Q_{j.})}_{\text{PS}_{jj}} - \underbrace{\delta Q}_{\text{D}_j} + \underbrace{\tau_j \sum_{k \in S} q_{jk}}_{\text{TR}_j}$$

where TR_j are non-member j's tariff revenues.

▶ Non-members' reaction functions

$$t_j = \frac{(n^2+4n-9)\alpha + 4(n+1)\delta - 2(n-1)(n+4)t_i}{2(n+1)}, \quad \frac{\partial t_j}{\partial t_i} < 0. \tag{24}$$

$$\tau_j = \frac{3(n-1)\alpha + 2(n+1)\delta - 2(2n-1)t_i}{2(n+1)}, \quad \frac{\partial \tau_j}{\partial t_i} < 0. \tag{25}$$

Remark 4 τ_j *is a strategic substitute of* t_i.

▶ Constraints on t_i.

$$t_i \geq t_j(n-1) \Leftrightarrow t_i \geq \underline{t_i^{hr}} = \frac{(n^2+4n-9)\alpha + 4(n+1)\delta}{2(n^2+4n-3)}. \tag{26}$$

$$q_{ji}(n-1, t_i) \geq 0 \Leftrightarrow t_i \leq \overline{t_i^{hr}} = \frac{\alpha(n-1)}{2n}. \tag{27}$$

▶ However, now we have that $\overline{t_i^{hr}} < \underline{t_i^{hr}}$ so that if $t_i \geq \underline{t_i^{hr}}$ then $q_{ji}(n-1, t_i) = 0$ (corner solution).

▶ If the non-signatory sets up a tariff on signatories' imports and the club tax is higher than the tax selected by the non-signatory, signatories' exports cannot access to the non-signatory's market.

- The stability function for the corner solution.

$$S(n,t_i) = \frac{g_0(n){t_i}^2 + g_1(n,\alpha,\delta)t_i + g_2(n,\alpha,\delta)}{2(n+1)^2}, \tag{28}$$

$$g_0(n) < 0,\ \ g_1(n,\alpha,\delta) > 0,\ \ g_2(n,\alpha,\delta) < 0. \tag{29}$$

Remark 5 *The stability function is strictly concave with respect to t_i.*

$$\max_{t_i} \sum_{i\in N} W_i(n,t_i)$$

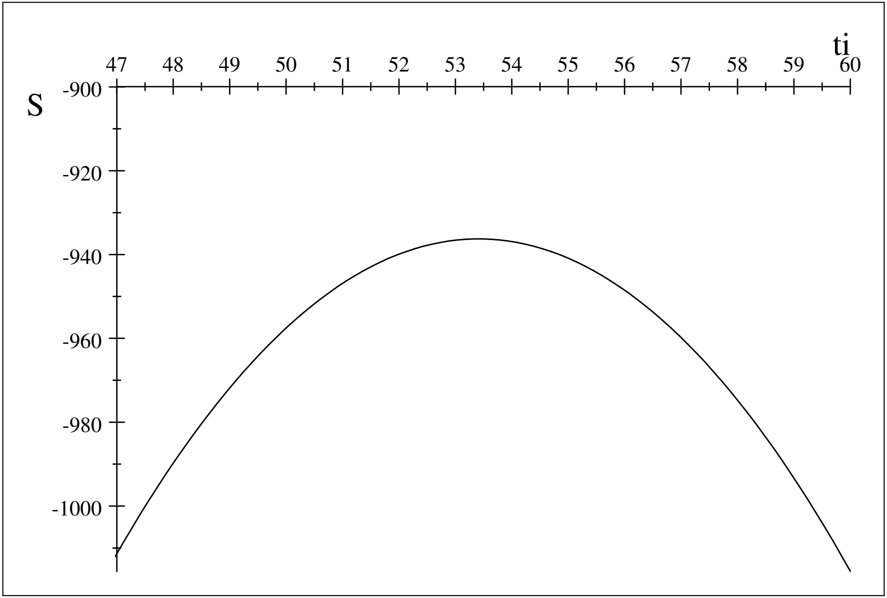
$$s.t.\ S(n,t_i) \geq 0,\ \ t_i \in [\underline{t_i^c}, \alpha].$$

Proposition (4)

With retaliation there does not exist a carbon tax that makes stable the grand coalition.

Proof If t_i^* is the maximum of $S(n,t_i)$ we obtain that $S(n,t_i^*) < 0$. Then the strict concavity of $S(n,t_i)$ implies that $S(n,t_i)$ for all $t_i \in [\underline{t_i^c}, \alpha]$.$\square$

- This result is also true for $\gamma \in (\gamma^+, 1)$ where γ^+ is a threshold value that decreases quickly with n ($\gamma^+(100) = 0.19$), and the interior solution for $\gamma = 0$.



α=100, n=10, δ=1, $\underline{t_i^c}$=53.66

Conclusions

- Without retaliation, there exists a second-best carbon tax for which the grand coalition is stable regardless of the degree of product differentiation.

- No BCAs will be applied at the equilibrium.

- With retaliation, the non-member's tariff is a strategic substitute of the club carbon tax.

- With retaliation, no carbon tax can stabilize the grand coalition regardless of the degree of product differentiation.

▶ Could there be stable agreements with less participation in this case?