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The tax competition game revisited: When leadership may be optimal

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Abstract

In this paper, we investigate the impact of leadership in a tax competition game. We show that leadership by a group of countries is pareto improving for each country (leaders and followers) compared to a Nash equilibrium outcome. In addition, a coalition of leaders is also pareto improving and this coalition is stable.

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1 Introduction

Taxation has been at the forefront of the recent international policy debate. This attention has notably stemmed from the concern that tax competition may affect the capacity of governments to collect tax revenues in times of fiscal consolidation. This paper analyses the impact of leadership on tax revenues in the context of multilateral strategic interactions between tax authorities.

The literature on tax competition relies on the assumption that capital owners are sensitive to net returns to capital when making portfolio choices or investment decisions. In standard models of tax competition capital mobility drives down capital tax rates. When tax revenues finance public goods, this results in an under-provision of local public goods that may negatively affect the welfare of citizens (e.g. Zodrow and Mieskovsky 1986, Wilson 1986, Wildasin 1988). Tax competition is good for welfare only when governments act as revenue-maximisers with the aim of increasing their size.

One solution typically advocated to mitigate harmful tax competition is policy coordination in order to internalize fiscal externalities. Repeated interactions can support tax cooperation and ensure tax efficiency (Cardarelli et al. 2002). In practice, full coordination is difficult to achieve. More recently, theoretical studies have analysed how partial co-ordination can emerge as an equilibrium outcome and restore a minimum level of tax efficiency. There, however, is no consensus on the effects of partial coordination in the literature. Turnovsky (1998) shows that in a real trade model with a tax game partial coordination is welfare improving compared to no coordination but worse than full coordination. By contrast, Sorensen (1996) shows that partial coordination delivers the worst outcome. Beaudry et al. (2000) have reconciled these seemingly contradicting results by showing that the inefficiencies arising from tax competition are reduced by partial coordination when spillovers are of identical sign within groups and between groups. Spillovers of the same sign enable all countries to increase their payoff, because they benefit from the internalization of externalities by the subset of countries that coordinate their policies. When spillovers are of opposite signs, the gains from coordination are achieved at the expense of countries outside the group. Finally, Sorensen (2004) refines this results by showing that the comparison between the gains from regional tax coordination and those from global cooperation depends on the degree of capital mobility. With imperfect capital mobility the gains from partial coordination are much larger than with perfect mobility, because imperfect capital mobility limits capital outflows from the subset of cooperative countries to the rest of the world, thereby allowing for higher tax rates.

A recent strand of empirical literature focuses on the estimation of tax reaction functions (national or local). It aims at empirically testing the magnitude of tax competition (see Brueckner's survey 2003) and the existence of potential tax leadership (see Altshuler and Goodspeed 2003 and de Mello 2007). In both cases, the role of leadership has been highlighted. Most theoretical studies investigating Stackelberg behaviors, however, assume a leadership position of a central government towards a lower tier of government (see Besley and Rosen 1998, Goodspeed 2000) and not between governments of the same tier. The leadership position of the central government generates tax reactions from the local governments to a change in the central policy which can mitigate or exacerbate tax competition inefficiency.

This paper analyses Nash vs. Stackelberg equilibria, under the possibility of partial co-operative behaviours. Can partial co-operation under Stackelberg leadership lead to higher tax revenues for all countries? Recent developments at the EU as well as at the G20 level suggests that the role of leadership in international tax cooperation deserves further attention. It is, for example, under the leadership of a group of countries and the European Union that automatic exchange of tax information seems to be gradually emerging as a new international standard.

Our model develops a N-country framework of tax competition between countries in a Stackelberg game. Our game exhibits positive spillovers and strategic complementarities. The main result of our paper is that leadership benefits to all countries and that the gains are higher when leaders cooperate. A Stackelberg equilibrium enables leaders to internalise the response of the followers to a change in their policies. It induces a higher tax rate that increases their revenues as well as the revenues of followers owing to the positive spillovers. When leaders cooperate, they further internalise the tax inefficiencies existing within the group of leaders. This increases tax rates and tax revenues in all countries.

The paper proceeds as follows. Section 2 introduces the basic N-country framework computing benchmark Nash vs. Stackelberg outcomes in a general model of tax competition. Section 3 applies the general setting to a standard tax competition game. Our concluding remarks are set out in Section 4.

2 The tax competition game

Let us consider a N-country[1] economy where countries are symmetric[2]. Governments tax income from a fixed and exogenously given supply of capital, the allocation of which satisfies:

$$\sum_{k=1}^{N} k_k = \bar{k} \tag{1}$$

Labor is assumed fixed in supply and perfectly immobile, while capital can move freely across countries. Governments raise taxes on capital according to the source principle of taxation. The arbitrage condition is:

$$r_k (1 - t_k) = \rho \qquad \forall k \in \{1, ..., N\} \tag{2}$$

where r_k stands for the country k gross return of capital.

In order to obtain tractable results, the production is assumed to be of Cobb-Douglas type with $f(k_k) = k_k^{1/2}$, so that the gross return to capital can be defined as:

$$r_k = \frac{1}{2} k_k^{-\frac{1}{2}} \tag{3}$$

[1] We can also refer to regions or municipalities.

[2] The assumption of symmetric regions is commonly assumed in standard tax competition models (see Wilson 1986, Wildasin 1988).

Capital market clearing yields the allocation of capital in each country as a function of tax rates in each country:

$$k_k = \overline{k}\frac{(1-t_k)^2}{\sum\limits_{l=1}^{N}(1-t_l)^2} \tag{4}$$

Governments compete to tax capital income:

$$R^k = k_k t_k r_k = \frac{1}{2}t_k\overline{k}^{1/2}\frac{(1-t_k)}{\left(\sum\limits_{l=1}^{N}(1-t_l)^2\right)^{1/2}} \tag{5}$$

2.1 The Nash solution

Each government acts as a Leviathan and maximizes its revenue $R^k(t_k, \mathbf{t}_{-k})$ with respect to its domestic tax rate where $\mathbf{t}_{-k}$ represents the set of taxes of the other countries. The N first order conditions[3]

$$R_1^k = R^k\left[1-\frac{t_k}{1-t_k}+\frac{(1-t_k)\,t_k}{\sum\limits_{l=1}^{N}(1-t_l)^2}\right] = 0 \;\forall k = 1,....,N \tag{6}$$

give the relation between the set of tax rates $\mathbf{t} := (t_1, ..., t_N)$:

$$t_k^N = \frac{N}{2N-1}$$

at the symmetric Nash equilibrium.

Note that $R_{11}^j < 0$, which implies that $R^k(t_k, t_{-k})$ is locally concave and guarantees that the Nash equilibrium obtained by the compilation of the N first order conditions for each country is a maximum.[4]

2.2 The Stackelberg equilibrium

In this section we analyze the properties of the Stackelberg equilibrium when there are F Followers and $N-F$ Leaders.

The revenue $R^j(t_j, \mathbf{t}_{-j}, \mathbf{t}_i)$ of a follower j with $j = 1...F$, $-j \neq j$ and $i = F+1.....N$ is defined as a function of the tax t_j, the set of taxes of the other followers, $\mathbf{t}_{-j}$, and the set of taxes of the leaders $\mathbf{t}_i$.

The revenue $R^i(t_i, \mathbf{t}_{-i}, \mathbf{t}_j)$ of a leader i with $i = F+1.....N$, $-i \neq i$ and $j = 1...N$ is defined as a function of the tax t_i, the set of taxes of the other leaders, $\mathbf{t}_{-i}$, and the set of taxes of the followers $\mathbf{t}_j$.

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[3] Where R_p is the first derivative of function R with respect to the pth argument and R_{pq} is the second derivative with the qth argument.

[4] $R_{11}^j = R^j\left(\frac{-(1+2t_j)(1-t_j)^2\sum\limits_{l\neq j}^{n}(1-t_l)^2-\left(\sum\limits_{l\neq j}^{n}(1-t_l)^2\right)^2}{\left(\sum\limits_{l=1}^{n}(1-t_l)^2\right)^2(1-t_j)^2}\right) < 0$

The followers' best response to the $(N-F)$ leaders' fixed policy is given by

$$R_1^j\left(t_j, \mathbf{t}_{-j}, \mathbf{t}_i\right) = 0$$

The $(N-F)$ leaders' best response are described by:

$$R_1^i\left(t_i, \mathbf{t}_{-i}, \mathbf{t}_j\right) + \sum_{j=1}^{F} R_3^i\left(t_i, \mathbf{t}_{-i}, \mathbf{t}_j\right) \frac{dt_j}{dt_i} = 0 \tag{7}$$

Following Etro (2008), the existence of a unique sub-game perfect symmetric Nash equilibrium is guaranteed if the contraction condition, hereafter referred as *Condition 1*, is satisfied: $R_{11}^F + R_{12}^F (F-1) < 0$.

Lemma 1 *For a sufficiently small number of countries, the contraction condition is always satisfied and there exists a unique subgame perfect Nash equilibrium.*

For a large number of countries, there exists a threshold $\overline{F}$ such that the contraction condition is verified iff $F < \overline{F}$.

Proof. The contraction condition writes:

$$R_{11}^j + R_{12}^j (F-1) = R^j \left(\frac{-\left(1+2t_j\right)\left(1-t_j\right)^2 - \sum\limits_{l \neq j}^{N} \left(1-t_l\right)^2 + (F-1)\left(1-t_{-j}\right) 2 \left(1-t_j\right)^3 t_j}{\left(\sum\limits_{l=1}^{N} \left(1-t_l\right)^2\right)\left(1-t_j\right)^2} \right)$$

since

$$R_{12}^j = R^j \left(1-t_{-j}\right) \left[\frac{2\left(1-t_j\right) t_j}{\sum\limits_{l=1}^{N} \left(1-t_l\right)^2} \right]$$

then we have to study the sign of

$$\begin{aligned} G(F) &= -\left(1+2t_j\right)\left(1-t_j\right)^2 \sum_{l \neq j}^{N} \left(1-t_l\right)^2 - \left(\sum_{l \neq j}^{N} \left(1-t_l\right)^2\right)^2 \\ &\quad + (F-1)\left(1-t_{-j}\right) 2 \left(1-t_j\right)^3 t_j \left(\sum_{l=1}^{N} \left(1-t_l\right)^2\right) \end{aligned}$$

rearranging (6) gives $\sum\limits_{l \neq i}^{N} \left(1-t_l\right)^2 = \frac{\left(1-t_j\right)^3}{2t_j - 1}$ which enables us to rewrite $G(F)$ as:

$$G(F) = \frac{\left(1-t_j\right)^3 \left(1-t_j\right)^2}{2t_j - 1} \left(-\left(1+2t_j\right) - \frac{\left(1-t_j\right)}{\left(2t_j - 1\right)} + (F-1)\left(1-t_{-j}\right) 2 \left(t_j\right)^2 \right)$$

which is increasing with F. When $F = 1$ then $G(F) < 0$ and when $F = N-1$ and $N \to \infty$, $G(F) > 0$. Then, there exists a number of followers $\overline{F}$ such that for each $F > \overline{F}$ we have $G(F) > 0$. ■

As a result, when N is sufficiently large, there exists a number of followers $\overline{F}$ such that for each $F > \overline{F}$ the contraction condition is not verified and the subgame Nash equilibrium does not exist or is not unique. In other words, to be sure that a sub game Nash equilibrium exists and is unique in the tax competition model, the number of leaders has to be sufficiently high. When N is small enough (e.g.. $N = 3$), the contraction condition is always satisfied for 1 or 2 leaders (e.g. $G(F) < 0$ for $F = 1$ or $F = 2$). The contraction condition ensures that the marginal revenue of a follower decreases following a simultaneous increase in all other followers' tax rates. This condition ensures that the equilibrium is a maximum.

Since spillovers and strategic interactions are the key elements to evaluate the efficiency of the Stackelberg equilibrium compared to the Nash equilibrium, let us specify the sign of spillovers and strategic interactions.

Result 1: *The objective function exhibits positive spillovers*

Proof. Directly from equation below

$$R_3^i = t_i \overline{k}^{-\frac{1}{2}} \frac{(1-t_i)^2 (1-t_j)}{\sum\limits_{l=1}^{N} (1-t_l)^2} > 0 \ \forall j \neq i$$

Result 2: *The objective function exhibits strategic complementarities if the number of players is sufficiently small or if the number of leaders is sufficiently large when the number of players is large.*

Proof. We have to determine the sign of $\frac{dt_j}{dt_i}$ for each $j = 1, ..., F$

The country j's reaction function of the F followers is:

$$R_1^j (t_j, \mathbf{t}_{-j}, \mathbf{t}_i) \text{ for } j = 1, ..., F$$

Differentiating this expression for each follower with respect to all arguments gives the F following equations:

$$\left[R_{11}^j\right] dt_j + \sum_{-j=1}^{F} \left[R_{12}^j\right] dt_{-j} + \sum_{i=F+1}^{N} \left[R_{13}^j\right] dt_i = 0 \ \forall j = 1, ..., F, \ i = F+1, ..., N \text{ and } -j \neq j \tag{8}$$

where $R_{11}^j < 0$ under *Condition 1.*

Since countries are symmetric, we should have, at the equilibrium $R_{11}^1 = R_{11}^2 = ... = R_{11}^F$ and $R_{12}^1 = R_{12}^2 = ... = R_{12}^F$.

Then we obtain:

$$\frac{dt_j}{dt_i} = -\frac{(N-F) R_{13}^F}{R_{11}^F + R_{12}^F (F-1)}$$

(see Appendix for detailed calculations). According to the contraction condition, the sign of the strategic interactions is given by the sign of R_{13}^F.

$$R_{13}^j = (1-t_i) R^j \left[\frac{2(1-t_j) t_j}{\sum\limits_{l=1}^{N} (1-t_l)^2}\right] > 0$$

and the game exhibits strategic complementarities. ∎

Proposition 2 *According to Lemma 1 and Results 1 and 2, the tax competition game exhibits the following results:*

i) A Stackelberg equilibrium exists and is unique if the number of leaders is sufficiently high

ii) Compared with the Nash equilibrium, each country receives a higher income when leadership exists.

iii) Compared with the Nash equilibrium and to the Stackelberg equilibrium with no cooperation between leaders, each country receives a higher income when leaders cooperate.

iv) The coalition of leaders is stable

Proof. see Appendix ■

Intuitively, result i) means that for an equilibrium to exist, the number of followers in a Stackelberg game must be limited to ensure that the tax base effect of followers is not too large.

Result ii) stipulates that the race to the bottom effect is reduced by internalizing the externalities of the followers in the leaders' choice. Leaders benefit from their leadership position and set a higher tax rate. Followers respond by applying also a higher tax rate because of strategic complementarities. This implies a higher tax revenue in every country due to positive spillovers.

When leaders cooperate (iii), an additional inefficiency is internalized by the leaders that cooperatively set a higher tax rate. This benefit all countries since followers respond by setting a higher tax rate.

Finally, the coalition is stable (iv) because no leader benefits from deviating from the coalition since he would loose the benefits from a higher tax rate without benefiting from a sufficient tax base effect.

3 Conclusion

Will tax competition in an increasingly globalised world result in a race to the bottom of tax rates on mobile factors and eventually reduce governments' ability to implement public policies? This fear may well be exaggerated. Simple tax competition models fail to capture important strategic features of international policy coordination that contribute to mitigating downward pressures on taxes. Groups of countries can indeed coordinate their tax policies and act as leaders in a more integrated world economy. Our theoretical findings suggest that such an equilibrium can exist, provided there is a sufficient number of countries agreeing on the coordination of their tax policies. Paradoxically, deeper world integration could make coordinated outcomes more likely to emerge through the establishment of international fora such as the G20 facilitating coalition building. At the same time, it is also likely that higher spillover effects in a more integrated world economy make the gains from cooperation higher for all public authorities owing to positive spillovers. This is the case in our model, since spillover effects increase in the number of countries and in the total amount of capital. Our paper assumes governments aim at maximising tax revenues. However, our results would also apply in models where government maximise welfare under some assumptions on the utility function. This would be the case in a setting with a simple linear utility function in which public goods are valued more than private goods (see Deveureux, Lockwood and Redoano 2008).

Appendix

Strategic interactions

The F FOC of the followers are given by:

$$R_{11}^{j}dt_j + R_{12}^{j}\sum_{\substack{-j=1\\-j\neq j}}^{F} dt_{-j} + R_{13}^{j}\sum_{i=F+1}^{N} dt_i = 0\forall j = 1, ..., F \tag{9}$$

which can be rewritten as

$$\frac{\left(R_{11}^{j} - R_{12}^{j}\right)}{R_{12}^{j}}dt_j + \sum_{-j=1}^{F} dt_{-j} + \frac{R_{13}^{j}}{R_{12}^{j}}\sum_{i=F+1}^{N} dt_i = 0\forall j = 1, ..., F \tag{10}$$

for a country $k \in [1, F]$, we can write

$$\frac{\left(R_{11}^{k} - R_{12}^{k}\right)}{R_{12}^{k}}dt_k + \sum_{-j=1}^{F} dt_{-j} + \frac{R_{13}^{k}}{R_{12}^{k}}\sum_{i=F+1}^{N} dt_i = 0 \tag{11}$$

by substraction of equations (10) and (11), we obtain:

$$\frac{\left(R_{11}^{j} - R_{12}^{j}\right)}{R_{12}^{j}}dt_j - \frac{\left(R_{11}^{k} - R_{12}^{k}\right)}{R_{12}^{k}}dt_k = \left(\frac{R_{13}^{k}}{R_{12}^{k}} - \frac{R_{13}^{j}}{R_{12}^{j}}\right)\sum_{i=F+1}^{N} dt_i$$

and then

$$dt_k = \frac{\left(R_{11}^{j} - R_{12}^{j}\right)R_{12}^{k}}{R_{12}^{j}\left(R_{11}^{k} - R_{12}^{k}\right)}dt_j - \frac{R_{12}^{k}}{\left(R_{11}^{k} - R_{12}^{k}\right)}\left(\frac{R_{13}^{k}}{R_{12}^{k}} - \frac{R_{13}^{j}}{R_{12}^{j}}\right)\sum_{i=F+1}^{N} dt_i \text{ with } \forall k = 1, ..., F$$

replacing in (9) gives

$$R_{11}^{j}dt_j + R_{12}^{j}\sum_{\substack{-j=1\\-j\neq j}}^{F}\left(\frac{\left(R_{11}^{j} - R_{12}^{j}\right)R_{12}^{-j}}{R_{12}^{j}\left(R_{11}^{-j} - R_{12}^{-j}\right)}dt_j - \frac{R_{12}^{-j}}{\left(R_{11}^{-j} - R_{12}^{-j}\right)}\left(\frac{R_{13}^{-j}}{R_{12}^{-j}} - \frac{R_{13}^{j}}{R_{12}^{j}}\right)\sum_{i=F+1}^{N} dt_i\right) + R_{13}^{j}\sum_{i=F+1}^{N} dt_i = 0$$

or

$$\left(R_{11}^{j} + \left(R_{11}^{j} - R_{12}^{j}\right)\sum_{\substack{-j=1\\-j\neq j}}^{F}\frac{R_{12}^{-j}}{\left(R_{11}^{-j} - R_{12}^{-j}\right)}\right)dt_j +$$
$$\left(R_{13}^{j} - R_{12}^{j}\sum_{\substack{-j=1\\-j\neq j}}^{F}\left(-\frac{R_{12}^{-j}}{\left(R_{11}^{-j} - R_{12}^{-j}\right)}\left(\frac{R_{13}^{-j}}{R_{12}^{-j}} - \frac{R_{13}^{j}}{R_{12}^{j}}\right)\right)\right)\sum_{i=F+1}^{N} dt_i = 0$$

We deduce the expression of $\frac{dt_j}{dt_i}$:

$$\frac{dt_j}{dt_i} = \frac{(N-F)\left(R_{13}^j - R_{12}^j \sum_{\substack{-j=1 \\ -j\neq j}}^{F} \left(-\frac{R_{12}^{-j}}{\left(R_{11}^{-j}-R_{12}^{-j}\right)}\left(\frac{R_{13}^{-j}}{R_{12}^{-j}} - \frac{R_{13}^{j}}{R_{12}^{j}}\right)\right)\right)}{R_{11}^j + \left(R_{11}^j - R_{12}^j\right) \sum_{\substack{-j=1 \\ -j\neq j}}^{F} \frac{R_{12}^{-j}}{\left(R_{11}^{-j}-R_{12}^{-j}\right)}}$$

At the symmetric equilibrium we have $R_{lm}^j = R_{lm}^F \forall j$ so that

$$\frac{dt_j}{dt_i} = \frac{(N-F)\left(R_{13}^F - R_{12}^F (F-1)\left(-\frac{R_{12}^{F}}{\left(R_{11}^{F}-R_{12}^{F}\right)}\underbrace{\left(\frac{R_{13}^{F}}{R_{12}^{F}} - \frac{R_{13}^{F}}{R_{12}^{F}}\right)}_{=0}\right)\right)}{R_{11}^F + \left(R_{11}^F - R_{12}^F\right)(F-1)\frac{R_{12}^{F}}{\left(R_{11}^{F}-R_{12}^{F}\right)}}$$

and finally

$$\frac{dt_j}{dt_i} = \frac{(N-F)\, R_{13}^F}{R_{11}^F + (F-1)\, R_{12}^F}$$

Proof of Proposition 1

i) Directly derived from lemma 1

ii) For the N-F leaders, the FOCs are given by

$$R_1^i \left(t_i, t_{-i}, t_j\right) + \sum_{j=1}^{F} R_3^i \left(t_i, t_{-i}, t_j\right) \frac{dt_j}{dt_i} = 0$$

At the Nash equilibrium, we get

$$R_1^i \left(t_i^N, t_{-i}^N, t_1^N\right) + \sum_{j=1}^{F} R_3^i \left(t_i^N, t_{-i}^N, t_j^N\right) \frac{dt_j}{dt_i} > 0$$

since

$$R_1^i \left(t_i^N, t_{-i}^N, t_1^N\right) = 0$$

positive spillovers imply

$$R_3^i \left(t_i^N, t_{-i}^N, t_1^N\right) > 0$$

and strategic complementarities imply $\frac{dt_j}{dt_i} > 0$

Then we can state that $t_i^S > t_i^N \;\; \forall\, i = F+1, ..., N$ and the sign of $\frac{dt_j}{dt_i}$ implies $t_j^S > t_1^N$. We can then conclude that

$$\begin{array}{rcl} R^i \left(t_i^S, t_{-i}^S, t_1^S\right) & > & R^i \left(t_i^N, t_{-i}^S, t_1^S\right) > R^i \left(t_i^N, t_{-i}^N, t_1^S\right) > R^i \left(t_i^N, t_{-i}^N, t_1^N\right) \\ & & \text{and} \\ R^j \left(t_j^S, t_{-j}^S, t_i^S\right) & > & R^j \left(t_j^N, t_{S-j}, t_i^S\right) > R^j \left(t_j^N, t_{-j}, t_i^N\right) \end{array}$$

the first part of the inequality recalls that t_j^S is the best response to t_i^S and t_{-j}^S and the second part of the inequality is true because of the sign of R_2^i and R_3^i and $t_j^S > t_j^N$ and $t_{-j}^S > t_{-j}^N$.

iii) When leaders cooperate, the leaders' objective becomes

$$\sum_i R^i\left(t_i, t_{-i}, t_j\right)$$

and the N-F FOCs are

$$R_1^i\left(t_i, t_{-i}, t_j\right)+\sum_{j=1}^{F} R_3^i\left(t_i, t_{-i}, t_j\right)\frac{dt_j}{dt_i}+\sum_{\substack{k=F+1\\k\neq i}}^{N} R_2^k\left(t_k, t_{-k}, t_j\right)+\sum_{j=1}^{F}\sum_{\substack{k=F+1\\k\neq i}}^{N} R_3^k\left(t_k, t_{-k}, t_j\right)\frac{dt_j}{dt_i}=0 \tag{12}$$

while the FOCs of the followers are unchanged, which implies that the expression for $\frac{dt_j}{dt_i}$ is also unchanged.

Rewriting (12) at the Stackelberg equilibrium (S) gives

$$\begin{aligned}&\underbrace{R_1^i\left(t_i^S, t_{-i}^S, t_j^S\right)+\sum_{j=1}^{F} R_3^i\left(t_i^S, t_{-i}^S, t_j^S\right)\frac{dt_j}{dt_i}}_{=0}+\sum_{\substack{k=F+1\\k\neq i}}^{N} R_2^k\left(t_k^S, t_{-k}^S, t_j^S\right)+\sum_{j=1}^{F}\sum_{\substack{k=F+1\\k\neq i}}^{N} R_3^k\left(t_k^S, t_{-k}^S, t_j^S\right)\frac{dt_j}{dt_i}\\ =\;&\sum_{\substack{k=F+1\\k\neq i}}^{N} R_2^k\left(t_k^S, t_{-k}^S, t_j^S\right)+\sum_{j=1}^{F}\sum_{\substack{k=F+1\\k\neq i}}^{N} R_3^k\left(t_k^S, t_{-k}^S, t_j^S\right)\frac{dt_j}{dt_i}>0\end{aligned} \tag{13}$$

The positive spillovers imply $R_2(.) > 0$ and $R_3(.) > 0$ whereas we have $\frac{dt_j}{dt_i} > 0$ for strategic complementarities.

(13) implies $t_i^{SC} > t_i^S$ and symmetrically we obtain $t_{-i}^{SC} > t_{-i}^S$. $\frac{dt_j}{dt_i} > 0$ implies $t_j^{SC} > t_j^{SN}$. Since the indirect objective functions exhibit positive spillovers we have $R^i\left(t_i^{SC}, t_j^{SC}, t_k^{SC}\right) > R^i\left(t_i^{SN}, t_j^{SN}, t_k^{SN}\right)$.

iv) We now want to check if this cooperation is stable. To do so, we shall evaluate the payoff of each player when one of the leader do not join the coalition, hereafter referred as D.

The country j's reaction function of the F followers is:

$$R_1^j = 0 \text{ for } j = 1, ..., F$$

whereas, the best responses of the $(N-F-1)$ leaders who cooperate are:

$$R_1^i\left(t_i, t_{-i}, t_j\right)+\sum_{j=1}^{F} R_3^i\left(t_i, t_{-i}, t_j\right)\frac{dt_j}{dt_i}+\sum_{k=F+2,k\neq i}^{N} R_2^k\left(t_k, t_{-k}, t_j\right)+\sum_{j=1}^{F}\sum_{k=F+2,k\neq i}^{N} R_3^k\left(t_k, t_{-k}, t_j\right)\frac{dt_j}{dt_i}=0 \tag{14}$$

and finally the best response of the leader who stays out of the coalition is

$$R_1^D\left(t_D, t_{-i}, t_j\right)+\sum_{j=1}^{F} R_3^D\left(t_D, t_{-i}, t_j\right)\frac{dt_j}{dt_D}=0 \tag{15}$$

Rewriting (14) at the Cooperative equilibrium (SC) gives

$$R_1^i\left(t_i^{SC},t_{-i}^{SC},t_j^{SC}\right)+\sum_{j=1}^{F}R_3^i\left(t_i^{SC},t_{-i}^{SC},t_j^{SC}\right)\frac{dt_j}{dt_i}+ \tag{16}$$

$$\sum_{\substack{k=F+1\\k\neq i}}^{N}R_2^k\left(t_k^{SC},t_{-k}^{SC},t_j^{SC}\right)+\sum_{j=1}^{F}\sum_{\substack{k=F+1\\k\neq i}}^{N}R_3^k\left(t_k^{SC},t_{-k}^{SC},t_j^{SC}\right)\frac{dt_j}{dt_i}$$

$$=-R_2^{F+1}\left(t_{F+1}^{S},t_{-k}^{S},t_j^{S}\right)-\sum_{j=1}^{F}R_3^{F+1}\left(t_{F+1}^{S},t_{-k}^{S},t_j^{S}\right)\frac{dt_j}{dt_i}<0 \tag{17}$$

The positive spillovers imply $R_2(.)>0$ and $R_3(.)>0$ whereas $\frac{dt_j}{dt_i}>0$ because of strategic complementarities.(13) implies $t_i^{SC}>t_i^D$ $\forall i=F+2,...,N$.

Rewriting (15) at the Cooperative equilibrium (SC) gives

$$R_1^D\left(t_D^{SC},t_{-i}^{SC},t_j^{SC}\right)+\sum_{j=1}^{F}R_3^D\left(t_i^{SC},t_{-i}^{SC},t_j^{SC}\right)\frac{dt_j}{dt_D}=-\sum_{\substack{k=F+1\\k\neq i}}^{N}R_2^k\left(t_k^{SC},t_{-k}^{SC},t_j^{SC}\right)$$

$$-\quad\sum_{j=1}^{F}\sum_{\substack{k=F+1\\k\neq i}}^{N}R_3^k\left(t_k^{SC},t_{-k}^{SC},t_j^{SC}\right)\frac{dt_j}{dt_i}<0 \text{ for } i=F+1 \tag{18}$$

and we obtain $t_{F+1}^{SC}>t_{F+1}^{D}$.

$\frac{dt_j}{dt_i}>0$ $\forall j,i$ implies $t_j^{SC}>t_j^D$ $\forall j$. Since the indirect objective functions exhibit positive spillovers we have $R^i\left(t_i^{SC},t_{-i}^{SC},t_j^{SC}\right)>R^i\left(t_i^D,t_{-i}^D,t_j^D\right)$ and $R^j\left(t_j^{SC},t_{-j}^{SC},t_i^{SC}\right)>R^j\left(t_j^D,t_{-j}^D,t_i^D\right)$.

Each player receives a higher income when the coalition involves all the leaders. Then, the coalition is stable.

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