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# **COORDINATION OF CAPITAL TAXATION AMONG A LARGE NUMBER OF ASYMMETRIC COUNTRIES**

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# Coordination of Capital Taxation Among a Large Number of Asymmetric Countries\*

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## Abstract

In this article, we examine international fiscal coordination in a world where markets are integrated but national governments are sovereign. The consequences of the liberalization of the capital market on national fiscal policies and possible remedies to resulting inefficiencies are analyzed. A simple model, with  $N$  countries where competitive firms produce a homogeneous good using mobile capital and immobile labor is considered. Fiscal competition arises between governments that have to tax capital and labor in order to raise fixed amounts of revenue. It is shown that capital mobility improves the capital allocation among countries since it enables capital owners to invest it in the country where capital is scarce. But fiscal competition leads to asymmetric capital taxation among countries and thus to a distortion on the international capital market.

Two fiscal reforms are considered: the introduction of a minimum capital tax level and the imposition of a tax range, i.e., a minimum plus a maximum capital tax level.

We show that the minimum tax reform is never preferred to fiscal competition by all countries while tax range reforms are unanimously accepted when it imposes convergence to the extreme taxes and does not change the international remuneration of capital.

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## 1. Introduction

The paper tackles the problem of international fiscal coordination in a world where markets are integrated but national governments are sovereign. The ongoing globalization movement allows a superior utilization of resources and a better allocation of risks among countries. If markets become more liberalized, national economies become more interdependent. Therefore a government has to take into account the behavior of its trade partners when undertaking local economic policies. It is no longer possible to envisage redistributive policies, the production of public goods or the fiscal policy without taking into account its effects on trade or capital flows. A possible consequence of this international interdependence is a downward pressure on the size of the public sector (cfr. Cremer and Al. (1996) for a survey of the literature). This can be viewed as a positive consequence if we consider the government as a growing and inefficient Leviathan and a negative one if we envisage a benevolent social planner.

In this paper, we consider the consequences for national fiscal policies of the liberalization of the capital market. We use a simple model, with  $N$  countries where competitive firms produce a homogeneous good using mobile capital and immobile labor. Fiscal competition arises between governments that have to tax capital and labor in order to levy a fixed amount of public money. The capital tax we consider here, as it concerns productive capital, has to be understood as **a corporate tax**.<sup>1</sup>

We show that capital mobility improves capital allocation among countries as it enables capital owners to invest in the country where capital is scarce. But fiscal competition leads to asymmetric capital taxation and thus to a distortion of the international capital market. More precisely, at equilibrium, the more a country imports capital, the larger its corporate tax. This is because a country importing capital, by taxing it, has part of its tax burden supported by foreign capital owners. Moreover, by taxing capital, a country depresses the international remuneration of capital and therefore decreases the cost it has to incur for the capital it imports.

The questions raised in this paper are important policy issues. Both the OECD and the European Commission have advocated fiscal harmonization; see OECD (1991) and the Ruding Report (1992), in reference to production efficiency.

The core of this paper is the analysis of possible remedies to the consequences of fiscal competition. We consider two fiscal reforms: the introduction of a minimum capital tax level and the imposition of a tax range, i.e. a minimum and a maximum capital tax level<sup>2</sup>.

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<sup>1</sup>This view is shared by most of the literature; see, for instance, Person and Tabellini (1992).

<sup>2</sup>The first reform has already been used by the European Union to decrease the inefficiency

Taking unanimity as a decision rule, we show that the minimum tax reform never passes and that tax range reforms are unanimously accepted when they impose convergence to the extreme of equilibrium taxes.

Fortunately, these reforms are simple, anonymous, and respect the subsidiary principle.<sup>3</sup> It is anonymous in that it applies to all countries in the same way, i.e., it restricts their strategy set and does not assign a particular tax level to each country. It respects the subsidiary principle in that it leaves the fiscal decision up to the nation while the supra-national interventions intend to limit inefficiencies.

It is possible to interpret this as an attempt to design supra-national (for Europe) or federal (for the Australia, Canada, or the US) institutions to help avoid inefficiencies linked to fiscal competition. The core of an institution is its jurisdiction and decision rule. The jurisdiction would be the setting of the tax range or the minimum tax level. We have selected unanimity as decision rule since it is the one used in the European Union.

If the model were empirically irrelevant, our policy propositions would be of little interest. In order to convince ourselves of the empirical relevance of the model, we computed correlations between statutory corporate tax levels and the extent of foreign capital ownership for the 14 EU members. This is not to a rigorous test since the measurements we use are rough estimates: We proxy the extent of the foreign ownership of capital in a country by aggregating its current account balance between 1990 and 1996. We would reject our theory if we observed a negative correlation between the statutory corporate tax of each country and the ratio between our proxy of foreign ownership of capital and the number of workers. Our sample consists of 14 members of the EU (all except Luxembourg for which we do not have all the data) and our data come from the IMF (1998) and the KPMG corporate tax survey 1998. We found a significant positive correlation and therefore were not able to reject our theory.<sup>4</sup>

The paper is organized as follows. In the next section discuss previous literature on fiscal competition. Section 3 describes the main features of our model. Section 4 is devoted to the description of the agents' preferences and to the derivation of a non-cooperative equilibrium. In section 5 we study the harmonization procedure and present the main results. Section 6 discusses further extensions of the model.

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from fiscal competition on value added tax.

<sup>3</sup>The subsidiarity principle states that decisions have to be taken at the lowest efficient level of government (supra national, national, or regional).

<sup>4</sup>To check if the correlation is significant we regressed the extent of foreign capital ownership divided by the active population on the statutory corporate tax level and found that this coefficient is significant at .99.

## 2. Related Literature

Several papers have investigated the scope for international income tax coordination. Some of them consider a fixed international remuneration of capital. Razin and Sadka (1991) showed that if there is no pure profit and all fiscal instruments are available, there is no scope for coordination as each country uses only residency-based tax and therefore no international externalities are created by fiscal policy. Huizinga and Nielsen (1996) show that there are cases for coordination when some pure profit exists. They argue that coordination is more important when foreign ownership is developed in each country.

The largest support for fiscal coordination comes from models which take into account endogenously determined capital remuneration. Bucovetsky and Wilson (1991), Persson and Tabellini (1992), Lopez, Marchand and Pestieau (1996) show that fiscal competition leads to under-provision of public goods or inefficient redistribution. Others, like Bucovetsky (1991) and Grazzini and van Ypersele (1996) are concerned about the efficient allocation of capital. They therefore consider a fixed public budget requirement. Both show that there is room for coordination.

This paper belongs to the last category. It differs from the existing literature in several ways. First, we allow heterogeneity among countries, in its population, as in Bucovetsky (1991), and in capital endowment. This leads to an asymmetric equilibrium to the non-cooperative game and enables us to more carefully address the problem of inefficient allocation of capital. Second, we consider a setting with an arbitrary number of countries. It does not add much to the description of a non-cooperative equilibrium, but provides a richer model with which to consider the different potential coordination policies. More importantly, we propose design for coordination policies in an environment that could be considered supranational institutions.

A non-negligible aspect of our result is that, contrary to Bucovetsky and Wilson (1991), fiscal coordination holds even when residence-based capital tax is allowed.

Our model builds on Grazzini and van Ypersele (1996). The first part of our analysis generalizes it by extending the number of countries (from two to  $N$ ) and by using a more general production function. It enables us to deconstruct the effect of fiscal policies on the welfare of each country in a more precise way. The most interesting innovations lie in the analysis of the tax reform proposition.

## 3. The model

Consider  $N$  sovereign countries that run a fiscal policy in order to balance their public budget. Each country is assumed to have an exogenously fixed budget re-

quirement  $G_i$ .<sup>5</sup> Fiscal policies consist of per unit factor taxes levied according to the source-based principle. The economy is described as follows: two production factors, capital  $K$  and labor  $L$ , are used in the production of a single consumption good. The production technology exhibits constant returns to scale and is described by a homogeneous production function  $F(K, L)$ :  $F(K, L) = Lf(k)$  with  $k = K/L$ ,  $f'(k) > 0$  and  $f''(k) < 0$ . To spare conditions on positive production and positive net remuneration of capital, we also assume that  $f'(0) = \infty$ ,  $f'(\infty) = 0$ ,  $f(0) = 0$ .

Firms behave competitively and production factors are therefore priced at their marginal productivity:

$$r = f'(k)$$

and

$$w = f(k) - kf'(k)$$

$r$  and  $w$  denoting respectively, the gross remuneration of capital and labor. The relative factor demand of a particular firm is given by:<sup>6</sup>

$$\tilde{k}(r) = f'^{-1}$$

with

$$\tilde{k}' = \frac{1}{f''(k)}.$$

It is assumed that capital is perfectly mobile and labor perfectly immobile. As taxes are levied according to the source-based principle, the capital is invested in the country giving the largest net remuneration. The following arbitrage condition holds:

$$r_i - t_i = r_j - t_j = \rho \quad \forall i = 1..N$$

where  $t_i$  is the per unit capital tax and  $\rho$  the net capital remuneration on the international market.

Countries are assumed to be asymmetric with respect to their factor endowment and we use  $\bar{K}_w$  and  $\bar{L}_w$  to denote the world aggregate endowment of capital and labor and  $\lambda_i > 0$  and  $\gamma_i > 0$ , the shares of the aggregate endowment owned by country  $i$ , so that  $\bar{L}_i = \lambda_i \bar{L}_w$  and  $\bar{K}_i = \gamma_i \bar{K}_w$ . Note that  $\sum_1^N \lambda_i = 1$  and  $\sum_1^N \gamma_i = 1$ .

For later use, we define  $\bar{k}_i = \frac{\bar{K}_i}{\bar{L}_i}$  and  $\bar{k}_w = \frac{\bar{K}_w}{\bar{L}_w}$ .

At the Walrasian equilibrium, factor prices adjust to clear markets. A labor market exists in each country and international markets are available for the capital and consumption goods. At equilibrium, labor markets clear in each country.

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<sup>5</sup>We denote the country variables with a subscript  $i$  where  $i = 1..N$ .

<sup>6</sup>Subscripts and dependent variables will be omitted when not absolutely necessary.

The international capital market clearing condition is therefore given by

$$\bar{L}_w \sum \lambda_i k_i(\rho, t_i) = \bar{K}_w.$$

As the LHS of this equation is strictly decreasing in  $\rho$ , an equilibrium exists,

$$\rho = \tilde{\rho}(t_1, \dots, t_i, \dots, t_n)$$

with

$$\rho_{t_i} = \frac{\partial \rho}{\partial t_i} = -\frac{\lambda_i \tilde{k}'_i}{\sum_{j=1}^N \lambda_j \tilde{k}'_j}.$$

At equilibrium the level of capital invested in each country is

$$K_i(\tilde{\rho}(t_1, \dots, t_i, \dots, t_n), t_i) = \lambda_i L_w \tilde{k}_i(\tilde{\rho}(t_1, \dots, t_i, \dots, t_n), t_i)$$

Therefore, the existing equilibrium wage rate is given by

$$w_i = f(\tilde{k}_i) - k_i f'(\tilde{k}_i)$$

with

$$\frac{\partial w_i}{\partial t_i} = -(\tilde{\rho}_{t_i} + 1)\tilde{k}_i < 0$$

for  $i = 1 \dots N$ , and

$$\frac{\partial w_i}{\partial t_j} = -\tilde{\rho}_{t_j} \tilde{k}_i > 0$$

for  $i = 1 \dots N$  and  $j \neq i$ .

It is important to note that capital movements originate from two sources: the difference in factor endowments and the difference in capital taxes. In the absence of capital taxes, capital movements lead to an equalization of the invested capital labor ratio across countries, i.e., to the efficient allocation of factors. Accordingly, liberalizing the capital market leads to a better allocation of resources, and capital taxes introduce distortions in the capital market. When capital taxes are not equalized across countries, some of the capital movements are not motivated by allocative efficiency but by fiscal opportunism.

## 4. Fiscal competition

In this section we analyze fiscal competition arising between the different countries. Capital and labor taxes are assumed to be decided simultaneously by each national social planner who maximizes the welfare of its representative consumer.

Tax setting is described as a non-cooperative game which strategies are tax levels and the payoffs are the countries representative agent's utility. First, we describe the public budget constraint and analyze for each country the effect of its national fiscal policy on the welfare of its representative consumer. Then, we characterize a non-cooperative equilibrium of the game we have just described.

#### 4.1. The government budget constraint

In country  $i$ , a fixed amount of public money,  $G_i$ , has to be levied through taxation. The fiscal choice lies in the allocation of the tax burden between labor and capital. Taxes are per unit and source-based.<sup>7</sup> The budget constraint of the government in country  $i$  is:

$$G_i = \lambda_i L_w (\tau_i + t_i k_i)$$

with  $\tau_i$  and  $t_i$  denoting respectively, labor and capital taxes. Indeed, the fiscal decision is essentially a one dimensional problem since  $\tau_i$  can be expressed as a function of  $t_i$ ,

$$\tau_i = \frac{G_i}{\lambda_i L_w} - t_i k_i.$$

It is important to note that the fiscal choice involves levying public money through a non-distortionary tax instrument and/or a distortionary one. The labor tax is non-distortionary as labor is inelastically supplied and immobile while the capital tax distorts the international price of capital.

Since no limits have been imposed on the tax instrument, it is possible to have negative taxes at equilibrium.

#### 4.2. The representative agent

In this subsection, we isolate the different effects of the capital tax on the welfare of a particular country.

The representative agent in country  $i$  derives welfare from consumption of the single good produced in the economy. His preferences can be represented by his country's per capita GNP, i.e., the value of the domestic product minus the net contribution from abroad:

$$U_i = (r_i k_i + w_i) - \rho(k_i - \bar{k}_i) \tag{4.1}$$

where  $\bar{k}_i = \frac{\bar{K}_i}{L_i}$  is the aggregate relative endowment of country  $i$  and  $k_i = \frac{K_i}{L_i}$  is the ratio of the factors of production effectively invested in country  $i$ .

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<sup>7</sup>We extend the analysis to the case where both source-based and residency-based taxes are available to the government.



The marginal effect of capital tax can be deconstructed into three effects: the *terms of trade effect*, the *tax import/export effect* and the *capital movement effect*. These are respectively identified in the following expression:

$$\frac{dU_i}{dt_i} = -\frac{d(\rho(k_i - \bar{k}_i))}{dt_i} \Big|_{k_i} + \frac{d(t_i(k_i - \bar{k}_i))}{dt_i} + (\bar{k}_i - k_i).$$

The *terms of trade effect* represents the gain (loss) that a capital-importing (exporting) country makes based on the depression of the international remuneration of capital induced by the increase in the capital tax. We call this the *terms of trade effect* as the logic behind it is exactly the one that justifies the optimum tariff in international trade: the tariff is seen as a way to influence the terms of trade. A country that imports capital has an incentive to increase its capital tax in order to decrease its cost. On the other hand, a capital-exporting country should decrease it in order to increase its international remuneration.

The *tax burden import/export effect*: When a capital-importing country levies a tax on capital, the resident owners as well as foreign investors pay the tax. Therefore part of the tax burden is supported by non-residents, i.e.  $t_i(k_i - \bar{k}_i)$ . By increasing the capital tax level, a capital-importing country influences the size of the tax burden that it exports. This effect is positive up to a certain point. For a capital-exporting country, the reverse is observed: each unit of exported capital is not taxed at home and is then a loss of tax revenue.

The residual effect of the fiscal policy is due to the influence of the induced capital movement on the gross remuneration of factors. A higher  $t_i$  decreases invested capital and then changes gross factor remuneration. We call it the *capital movement effect*. This effect is negative (resp. positive) if the country is a capital importer (resp. exporter). The logic behind it is that  $\frac{dw}{dk} = -k_i \frac{dr}{dk}$ : an additional unit of capital invested at home increases a labor remuneration more than capital remuneration when the country is a capital importer.

In order to save ourselves tedious calculations, it is assumed that the utility functions are continuous, strictly quasi-concave with respect to their capital tax rate and that  $\frac{\partial^2 U_i}{\partial t_i \partial t_j} \geq 0$ . We present an example satisfying all these assumptions in the appendix.

### 4.3. The non-cooperative fiscal decision

It is now possible to formally describe a non-cooperative game played by the different countries. It is an  $N$  player game which players are the national social planners and which strategies are the level of capital tax.

The payoffs of the game are:

$$\pi_i(t_1, \dots, t_N) = \bar{k}_i \rho(t_1, \dots, t_N) + w(t_1, \dots, t_N) + t_i k_i(t_1, \dots, t_N) \quad (4.2)$$

$\forall i = 1, \dots, N$ . The strategies are

$$t_i \in [-\infty, \infty] \quad \forall i = 1, \dots, N. \quad (4.3)$$

The best reply function of country  $i$ ,  $\tilde{t}_i(t_{-i})$  is implicitly defined by the F.O.C of the maximization problem of its social planner:

$$(1 + \rho_{t_i}) k'_i t_i + (\bar{k}_i - k_i) \rho_{t_i} = 0, \quad (4.4)$$

which is equivalent to

$$t_i = -\frac{\rho_{t_i}}{1 + \rho_{t_i}} \frac{(\bar{k}_i - k_i)}{k'_i}. \quad (4.5)$$

By the implicit function theorem, and the assumptions on the utility functions,

$$\frac{\partial \tilde{t}_i}{\partial t_j} = -\frac{\partial^2 U_i / \partial t_j \partial t_i}{\partial^2 U_i / \partial t_i^2} > 0. \quad (4.6)$$

In other words capital taxes are strategic complements. An equilibrium of the non-cooperative game is given by the solution of the system of equations defined by the  $N$  best-reply functions defined by (4.5).

**Proposition 4.1.** (i) *The game defined by equations (4.2) and (4.3) has a non-cooperative equilibrium  $(t_1^{nc}, \dots, t_N^{nc})$ . (ii) The equilibrium capital tax levels are such that capital-importing countries set positive capital taxes while capital-exporting countries subsidize it. (iii) Moreover, at equilibrium, the capital is almost never efficiently allocated among countries.*

**Proof.** (ii) We know that, at equilibrium, countries are on their best-reply functions(?).  $t_i \geq (<)0$  when  $(\bar{k}_i - k_i) \leq (>)0$ .

(i) This type of game has an equilibrium when payoff functions are continuous and quasi-concave, and when the strategy sets are compact and convex. As the two first conditions are assumptions of our model, we need to show that strategy sets are convex and compact. As capital tax rates are unidimensional strategy sets, we have to show that they are bounded from below and above. The demonstration is done by contradiction for the upper limit. Imagine that a country,  $i$ , sets an infinite tax at equilibrium, then  $r_i = \infty$  and, by the assumptions on the production function,  $k_i = 0$  and therefore

the country is exporting capital. This is impossible since we showed in (ii) that only capital-importing countries set positive capital tax. Following a similar argument, it is easy to show that the strategy sets are bounded from below.

(iii) The capital is efficiently allocated across countries when its cost is equalized. Since the cost is given by the international price of capital plus the national capital tax rate, costs are equalized only when all countries set the same level of capital tax. This is the case only when countries are symmetric. ■

Even if at a first glance, the results seem surprising, proposition 4.1 is rather intuitive when analyzed with the three effects of capital taxation in mind.

When the capital tax is not too high, capital taxation has two positive effects on welfare for a capital-importing country: a decrease in their capital import bill via the **terms-of-trade effect** and an alleviation of the tax burden with the **tax burden export effect**. Only the **capital movement effect** bridles the capital taxation willingness of these countries. Capital taxation has the opposite results for a capital-exporting country. There is a negative incentive to tax since they fear a loss of their tax base and want to get the highest return from the capital they export.

Note here that the inefficiencies identified in this proposition would not exist if countries were symmetric in their relative capital endowment. In this latter case, at equilibrium, capital is not taxed in any of the countries and thus there is no inefficiency in the capital market. In this paper it is the asymmetry between countries that causes inefficiency and not the factor supply elasticity as in Bucovetsky and Wilson (1991) or Huizinga and Nielsen (1996).

Since the allocation of capital is inefficient at a non-cooperative equilibrium, it makes sense to explore possible coordination devices.

## 5. Fiscal Reforms

In this section we analyze two reforms: *the minimum tax reform* and *the tax range reform*.

For simplicity, we focus on cases where the equilibrium of the non cooperative game is unique. For further reference, countries are labeled such that  $t_1^{nc} \leq t_2^{nc} \dots \leq t_N^{nc}$  with  $t^{nc}$  denoting the value of the taxes at the non-cooperative equilibrium.

### 5.1. The minimum tax reform

The minimum tax reform is a natural candidate since it has already been used to overcome inefficiencies arising from fiscal competition on the VAT in European Union and has been proposed in the Ruding proposition of the EU..

In this section, we argue that, under the assumptions of our model, this reform cannot be accepted by all countries. The capital-exporting countries reject it while the capital-importing countries advocate it. To show this we first have to derive the Nash equilibrium of the game where the agents strategies are constrained from below. We define this as the *tax constrained game*. We then show that any increase in the minimum tax level injures the capital-exporting countries.

The strategies of this constrained game are all the capital tax levels higher than the minimum tax level,  $\underline{\delta}$ , and the payoffs, the welfare of the representative consumer in each country. Lets define  $B(\underline{\delta})$  as the set of countries bounded when the minimum tax level is  $\underline{\delta}$  and  $\beta(\underline{\delta})$  the largest country index of  $B(\underline{\delta})$ .

**Lemma 5.1.** *The tax constrained game has an equilibrium  $(\tilde{t}_1^c(\underline{\delta}), \dots, \tilde{t}_i^c(\underline{\delta}), \dots, \tilde{t}_N^c(\underline{\delta}))$ , where  $\tilde{t}_i^c(\underline{\delta}) = \underline{\delta}$  for  $i \leq \beta(\underline{\delta})$  and  $\frac{d\tilde{t}_i^c(\underline{\delta})}{d\underline{\delta}} > 0$  for  $i > \beta(\underline{\delta})$ .*

**Proof.** Since strategy sets are compact and convex and payoffs are quasi-concave and continuous functions, the equilibrium exists. The equilibrium taxes are increasing functions of the minimum tax level because they are strategic complements as shown in (4.6). ■

This shows that for each level of the minimum tax rate, an equilibrium exists. Let us now state the following proposition:

**Proposition 5.2.** *The minimum tax reform is never unanimously accepted.*

**Proof.** Since a reform passes only if it is weakly preferred by all countries and strictly preferred by at least one, it is enough to show that an increase in  $\underline{\delta}$  is detrimental for at least one country. We do this for a non-constrained country.

By differentiating the welfare of an agent  $i$  at the constrained equilibrium  $(\tilde{t}_1^c(\underline{\delta}), \dots, \tilde{t}_i^c(\underline{\delta}), \dots, \tilde{t}_N^c(\underline{\delta}))$  with respect to  $\underline{\delta}$

$$\frac{dU_i}{d\underline{\delta}} = \frac{dU_i}{dt_i^c} \frac{dt_i^c}{d\underline{\delta}} + \sum_{j \neq i}^N \frac{dU_i}{dt_j^c} \frac{dt_j^c}{d\underline{\delta}} \quad (5.1)$$

Because country  $i$  is not constrained, it is on its best reply and thus  $\frac{dU_i}{dt_i^c} = 0$ . Moreover,

$$\frac{dU_i}{dt_j^c} = \rho_{t_j} \frac{(\bar{k}_i - k_i)}{1 + \rho_{t_i}}$$

Then,

$$\frac{dU_i}{d\underline{\delta}} = \frac{(\bar{k}_i - k_i)}{1 + \rho_{t_i}} \sum_{j=1}^N \rho_{t_j} \frac{dt_j}{d\underline{\delta}} \quad (5.2)$$

This expression is negative (resp. positive) when the country  $i$  exports (resp. imports) capital. There is a conflict of interest between the capital-importing and the capital-exporting countries. For completeness, we have to consider the case where none of the capital-exporting countries are unbounded. To see that it is also detrimental for a bounded country, just note that this country is forced to set a capital tax higher than its optimal one. This means that  $\frac{dU_i}{dt_i^c} < 0$ , knowing that  $\sum_{j \neq i}^N \frac{dU_i}{dt_j^c} \frac{dt_j^c}{d\bar{\delta}} = \frac{(\bar{k}_i - k_i)}{1 + \rho_{t_i}} \sum_{j=1}^N \rho_{t_j} \frac{dt_j}{d\bar{\delta}}$ , by (5.1) it is straightforward that  $\frac{dU_i}{d\bar{\delta}} < 0$ . ■

A rough intuition of this result is the following. Since the minimum tax can be binding for the capital-exporting countries, bounded countries have to give up more of their tax base than they would like. This is detrimental for them and positive for the capital-importing countries that have the opportunity to export more of their tax burden.

In our model, this means that if the European Union wants to pass this kind of reform, capital-exporting countries have to be compensated. Even if this is not impossible, it is nevertheless interesting to find another tax reform that would be self contained. We will develop this further in the next section.

## 5.2. The tax range reform

A tax range reform is defined as the imposition of a lower ( $\underline{\delta}$ ) and an upper ( $\bar{\delta}$ ) limit to the capital tax level. The tax range is given by  $[\underline{\delta}, \bar{\delta}]$ .

We show that tax reforms that are unanimously preferred to the non-cooperative equilibrium do exist. The success of this reform comes precisely from the weakness of the former. If it is detrimental for the capital-exporting countries to be bound from below and positive for the capital-importing countries, it is reasonable to expect the opposite effect from an upper boundary. As both policies decrease the inter-country difference in capital cost, it improves the capital allocation efficiency. We can therefore expect a net gain from the combination of these two reforms.

In terms of the minimum tax reform, we first compute the constrained Nash equilibrium; we then show that it can be Pareto improving.

The constrained Nash equilibrium is defined by the game which strategies are all the capital tax levels in the tax range,  $[\underline{\delta}, \bar{\delta}]$  and the payoffs are the welfare of each representative consumer.

For a given tax range, define  $B(\underline{\delta}, \bar{\delta})$  as the set of countries that are bounded from below and  $T(\underline{\delta}, \bar{\delta})$  as the set of countries bounded from the top.

Let also define  $\beta(\underline{\delta}, \bar{\delta}) = 1 + \max_i B(\underline{\delta}, \bar{\delta})$  and  $\theta(\underline{\delta}, \bar{\delta}) = \min_i T(\underline{\delta}, \bar{\delta}) - 1$ .  $\beta$  is then the index of the unbound country with the lowest capital tax and  $\theta$  is the index of the unbound country with the highest capital tax.

**Lemma 5.3.** *This game has an equilibrium  $(\tilde{t}^C_1, \dots, \tilde{t}^C_i, \dots, \tilde{t}^C_N)$ , where  $\tilde{t}^C_i = \underline{\delta}$  when  $i < \beta(\underline{\delta}, \bar{\delta})$ ,  $\tilde{t}^C_i = \bar{\delta}$  for  $i \geq \theta(\underline{\delta}, \bar{\delta})$  and  $\tilde{t}^C_i = \tilde{t}^C_i(\underline{\delta}, \bar{\delta})$  when  $\beta(\underline{\delta}, \bar{\delta}) < i < \theta(\underline{\delta}, \bar{\delta})$ . Where  $\frac{dt^C}{d\underline{\delta}} \geq 0$  and  $\frac{dt^C}{d\bar{\delta}} \geq 0$ .*

**Proof.** By the usual argument, the existence of the equilibrium is ensured. As capital taxes are strategic complements,  $\frac{dt^C}{d\underline{\delta}} \geq 0$  and  $\frac{dt^C}{d\bar{\delta}} \geq 0$ . ■

Each tax range corresponds to a constrained Nash equilibrium. We now turn to the analysis of impact of a tax range reform  $d\underline{\delta}$ ,  $d\bar{\delta}$  on the welfare of the different representative agents.

A **country bounded from below, i.e.**  $i < \beta$ , has the following welfare function

$$U_i = \rho \bar{k}_i + w_i + \underline{\delta} k_i.$$

Differentiating it with respect to  $\underline{\delta}$ , we get the welfare effect of an increase in the lower bound,

$$\frac{dU_i}{d\underline{\delta}} = \frac{d\rho}{d\underline{\delta}}(\bar{k}_i - k_i) + \underline{\delta} \dot{k}_i \left(1 + \frac{d\rho}{d\underline{\delta}}\right).$$

Similarly, for the upper bound,

$$\frac{dU_i}{d\bar{\delta}} = \frac{d\rho}{d\bar{\delta}}(\bar{k}_i - k_i) + \underline{\delta} \dot{k}_i \frac{d\rho}{d\bar{\delta}}.$$

The total effect is given by,

$$dU_i = \frac{dU_i}{d\underline{\delta}} d\underline{\delta} + \frac{dU_i}{d\bar{\delta}} d\bar{\delta} = \underline{\delta} \dot{k}_i d\underline{\delta} + \left(\frac{d\rho}{d\underline{\delta}} d\underline{\delta} + \frac{d\rho}{d\bar{\delta}} d\bar{\delta}\right)(\bar{k}_i - k_i + \underline{\delta} \dot{k}_i). \quad (5.3)$$

By exactly the same procedure it is easy to show that, for **countries bounded from above**,

$$dU_i = \frac{dU_i}{d\underline{\delta}} d\underline{\delta} + \frac{dU_i}{d\bar{\delta}} d\bar{\delta} = \bar{\delta} \dot{k}_i d\bar{\delta} + \left(\frac{d\rho}{d\underline{\delta}} d\underline{\delta} + \frac{d\rho}{d\bar{\delta}} d\bar{\delta}\right)(\bar{k}_i - k_i + \bar{\delta} \dot{k}_i). \quad (5.4)$$

The welfare effect of a tax range reform on **an unbounded country** is a little more difficult to find.

The welfare of an unbounded country is given by

$$U_i = \rho \bar{k}_i + w_i + \tilde{t}^C_i(\underline{\delta}, \bar{\delta}) k_i.$$

Differentiating with respect to both boundaries, we get

$$\frac{dU_i}{d\delta} = (\bar{k}_i - k_i) \frac{d\rho}{d\delta} + t_i \dot{k}_i \left( \frac{dt_i}{d\delta} + \frac{d\rho}{d\delta} \right)$$

with  $\delta = \underline{\delta}, \bar{\delta}$ .

The total effect of the reform is then

$$dU_i = (\bar{k}_i - k_i + t_i \dot{k}_i) d\rho + t_i \dot{k}_i dt_i \quad (5.5)$$

with  $dx = \frac{dx}{d\underline{\delta}} d\underline{\delta} + \frac{dx}{d\bar{\delta}} d\bar{\delta}$ .

It is now possible to show the following proposition.

**Proposition 5.4.** *Tax range reforms that leave international remuneration of capital unchanged and increase the elasticity of the international demand for capital exist and are always accepted as long as  $d\underline{\delta} > 0$ ,  $d\bar{\delta} < 0$  and  $0 \in [\underline{\delta}, \bar{\delta}]$ . Moreover, as a result of the tax reform, all capital-exporting countries increase their capital tax and all capital-importing ones decrease it.*

**Proof.** From (5.3), (5.4) and (5.5), it directly follows that  
when  $i < \beta$ ,

$$dU_i = \underline{\delta} \dot{k}_i d\underline{\delta} \geq 0 \text{ as long as } d\underline{\delta} > 0 \text{ and } \underline{\delta} \leq 0,$$

and, when  $i > \theta$ ,

$$dU_i = \bar{\delta} \dot{k}_i d\bar{\delta} \geq 0 \text{ as long as } d\bar{\delta} < 0 \text{ and } \bar{\delta} \geq 0,$$

where the conditions on the boundaries and on the reforms are equivalent to the one stated in the proposition;

when  $i \in [\beta, \theta]$ ,

$$dU_i = t_i \dot{k}_i dt_i,$$

As by setting  $t_i^{\tilde{C}}$  equal to its capital tax to its tax before, unbounded countries can secure the pre-reform welfare, if they change their equilibrium strategy, it is for the better.

This is,  $dU_i > 0$  and, by the former equation,  $dt_i \geq (\leq) 0$  when country  $i$  is a capital exporter (importer).

Under these conditions, all countries are better off. The reform then passes.

To complete the proof, we have to show that such reform exists and increases the elasticity of the international demand for capital.

■

The intuition behind this result is the following.

As  $\rho$  is unchanged, the term of trade effect on welfare is neutralized. A tax range reform is a mix between a minimum tax increase and a maximum tax decrease. An increase in the minimum tax hurts capital-exporting countries, because of the *tax burden effect*, as they are forced to give up more than they would like of their tax base. This effect is, however, attenuated by the increase in their gross income described by the *capital movement effect*. The capital-importing countries are affected in the opposite way. They are able to export more of their tax burden but have to pay a tribute, the decrease in their gross income. The decrease in the maximum tax affects countries in exactly the opposite way. The tax burden effect is used as a built-in mechanism to transfer resources from the country that gains to compensate the countries suffers. capital-exporting countries benefit from the efficiency gain and compensate the capital-importing countries.

The efficiency gains are larger than the one directly created by the convergence of the boundaries: there are gains due to the additional convergence of the countries that are not bounded by the reform. This additional convergence is explained by the increased elasticity of the international demand for capital: all capital-importing (exporting) countries have an incentive to increase (decrease) their capital tax because the terms of trade effect are augmented. (From the welfare point of view, the terms-of-trade effects are neutralized, but the marginal effect of capital tax described by the terms-of-trade effect is affected). This causes a further convergence of the capital taxes and thus an additional increase in efficiency.

In this proposition, the zero capital tax rate seems to be important, which is not surprising since labor tax is non-distortionary. We can reasonably conjecture that if labor supply were inelastic, a positive capital tax rate would play this role.

Both reforms have the appealing properties of being simple, anonymous and respecting the subsidiary principle. By anonymous we mean that the minimum tax or the range is the same way for all countries, i.e., it restricts their strategy set. A non-anonymous reform would impose a different tax level on each country. In the context of our model it does not make a big difference. A minimum tax or tax range reform is mimicked by imposing to each country the capital tax level that they would have announced under the minimum tax reform or the tax range reform. An anonymous rule is desirable because: (i) The informational requirement in imposing such reforms is lower, and (ii) a non-anonymous reform would be politically difficult to sustain.

The proposed reforms respect the subsidiary principle since they leave the fiscal decision to the state while the supra-national interventions intend to limit inefficiencies.

A more ambitious way of interpreting this work is to see it as an attempt to design supra-national (for Europe) or federal (for Australia, Canada or the US)



institutions to avoid the inefficiencies linked to fiscal competition.

An institution consists of competencies and a decision rule. The competencies would be the setting of the tax range. For the decision rule, we propose the unanimity rule since it prevails throughout the European Union on these matters and with the behavior of independent countries in international negotiations. Some of the required features of this institution would be to respect the anonymity and the subsidiary principles. For instance, the WTO, with its *most preferred clause*, requires each country to treat all their trade partners equally.

## 6. Additional discussion

It is important to note that in this paper, the source-based capital tax would be used even if a residency-base version were available to the government. The existence of a residency-based tax would only enable the government to reallocate part of the tax burden from the workers to the capital owners. The source-based capital tax would still be used as a strategic device.

We want to discuss the following extension: Imagine that the three tax instruments were available and that factor supplies are not perfectly (but fairly) inelastic. The conclusions of our model wouldn't change, the non-cooperative equilibrium would consist of source-based and residency-based taxes and a labor tax for each country. The source-based capital tax wouldn't change since factor supplies are quite inelastic. But the residual tax burden would be split among the capital income and the labor residency-based taxes to minimize the distortions due to the factor supply elasticity.

Imagine now, that tax evasion is possible and is done at no risk. To evade tax at no risk, a capital owner has to get the income of his capital from a non-national institution. For instance, the Belgian capital owner gets his dividend from a Luxembourg bank even though his capital is invested in Belgium. The residency-based tax would then be zero as it is not possible to implement it. In this case, the introduction of a minimum withholding tax would please all countries since it enables the government to use this instrument at least up to the minimum tax level and therefore decreases the inefficiencies linked to the factor supply elasticity. Typically, the minimum withholding tax would be the lowest one out of the set of the nationally preferred residency-based capital without tax evasion.

The introduction of a minimum capital tax would undoubtedly pass. To reach this conclusion, it has to be assumed that no profit is made by the banks distributing the benefits and no risks are taken by the tax evaders. This is typically not the case and explains our observation of a positive residency-based capital tax in Europe and that countries that attract most of these financial benefits try to

block these kinds of reforms.

## 7. Conclusion

In this paper we have analyzed fiscal competition between  $N$  asymmetric countries when international capital market is liberalized. We have focused our analysis on the effect of this competition on the allocation of capital among countries, i.e., on production efficiency. We deconstruct the impact of fiscal policy into three effects: the *terms of trade effect*, the *tax import/export effect* and the *capital movement effect*.

We have shown that, when countries behave non-cooperatively, at equilibrium, the capital tax level differs between countries leading to an inefficient allocation of resources. We examined two tax reforms, one that imposes a minimum tax and another that fixes a range in which capital tax levels have to be decided.

We showed that the first reform would not be unanimously accepted and that the second reform would pass as long as the convergence of tax limits is such that the international remuneration of capital is not affected. The  $N$  countries framework is important here, as the effects of the reforms are different for countries that are bounded and those that are unbounded.

We argued that the tax range reform plus the unanimity rule could be an interesting starting point for discussion of a supranational or federal fiscal institution since it contains some appealing principles like the anonymity of the reforms and the subsidiary principle.

This paper helps to identify how asymmetry between a large number of countries plays an important role in the fiscal competition and what kind of reforms could pass. In addition it provides for several interesting extensions for the economic and institutional points of view.

## 8. Appendix

In this appendix, considering a particular example, we show, with some lemmas, that the analysis we undertook in this paper is not vain, i.e. we were not reasoning on an empty set.

Consider the following constant returns to scale production function in intensive form:

$$f(k) = (a - bk)k$$

This function has been used by Bucovetsky and Grazzini and van Ypersele. It perfectly fits in the assumptions we impose except for two technical conditions

i.e.  $f'(0) = \infty$ ,  $f'(\infty) = 0$ . These conditions have to be replaced by  $\bar{k}_i < \frac{a}{2b\gamma_i}$ , in order to ensure positive marginal productivity.

**Lemma 0.1.**  $\frac{d^2 U_i}{dt_i^2} < 0$  and  $\frac{d^2 U_i}{dt_j dt_i} > 0$ .

**Proof.** Mutatis mutandis equation (4.4),

$$\frac{dU_i}{dt_i} = 2b\lambda_i(\bar{k}_w - \bar{k}_i) + \gamma_i \sum_{j=1}^N \lambda_j t_j - t_i = 0 \quad (0.1)$$

It directly follows that  $\frac{d^2 U_i}{dt_i^2} = (\lambda_i^2 - 1) < 0$  and  $\frac{d^2 U_i}{dt_j dt_i} = \lambda_j \lambda_i > 0$ . ■

**Lemma 0.2.** *The non-cooperative equilibrium exists and is unique.*

**Proof.** The Nash equilibrium solves the system of equations defined by (0.1) for the N countries. This system is linear and of full rank. The solution is then unique given by

$$t_i^{nc} = 2bk_w \left( \lambda_i \frac{1 - \sum_{j=1}^N \gamma_j \lambda_j}{1 - \sum_{j=1}^N \lambda_j^2} - \gamma_i \right) \text{ for all } i = 1 \dots N$$

■

**Lemma 0.3.** *For all tax range  $[\underline{\delta}, \bar{\delta}]$ , an equilibrium of the constrained game exists and is unique.*

**Proof.** The equilibrium of the constrained game solves the system of equations of the non-constrained countries: is unique, as this is a non-homogeneous system of equations.

$$\tilde{t}_i(t_{-i}) = \frac{\lambda_i}{1 - \lambda_i^2} \left( 2b\bar{k}_w \left( 1 - \frac{\gamma_i}{\lambda_i} \right) + \underline{\delta} \sum_{j=1}^{\beta} \lambda_j + \bar{\delta} \sum_{j=\theta}^N \lambda_j + \sum_{j=\beta}^{\theta} \lambda_j t_j \right)$$

In matrix form,

$$\begin{bmatrix} 1 & -\frac{\lambda_{\beta}}{1+\lambda_{\beta}} \lambda_{\beta+1} & \dots & -\frac{\lambda_{\beta}}{1+\lambda_{\beta}} \lambda_{\theta} \\ -\frac{\lambda_{\beta+1}}{1+\lambda_{\beta+1}} \lambda_{\beta} & 1 & & \dots \\ \dots & & \dots & \\ -\frac{\lambda_{\theta}}{1+\lambda_{\theta}} \lambda_{\beta} & \dots & & 1 \end{bmatrix} \begin{bmatrix} t_{\beta} \\ t_{\beta+1} \\ \dots \\ t_{\theta} \end{bmatrix} = \begin{bmatrix} \frac{\lambda_{\beta}}{1-\lambda_{\beta}^2} A_{\beta} \\ \frac{\lambda_{\beta+1}}{1-\lambda_{\beta+1}^2} A_{\beta+1} \\ \dots \\ \frac{\lambda_{\theta}}{1-\lambda_{\theta}^2} A_{\theta} \end{bmatrix}$$

with  $A_i = 2b\bar{k}_w(1 - \frac{\gamma_i}{\lambda_i}) + \underline{\delta} \sum_{j=1}^{\beta(\underline{\delta}, \bar{\delta})} \lambda_j + \bar{\delta} \sum_{j=\theta(\underline{\delta}, \bar{\delta})}^N \lambda_j$

Applying Cramer's rule and standard matrix calculus results, we get

$$t_i^C = \frac{\lambda_i(\sum_{j=\beta \neq i}^{\theta} A_j \lambda_j^2 - A_i \lambda_i^2(\sum_{j=\beta \neq i}^{\theta} \lambda_j^2 - 1))}{1 - \sum_{j=\beta+1}^{\theta-1} \lambda_j^2} \text{ for all } i \text{ such that } \beta \leq i \leq \theta$$

and

$$t_i^C = \underline{\delta} \text{ for all } i < \beta \text{ and } t_i^C = \bar{\delta} \text{ for all } i > \theta.$$

■

**Lemma 0.4.** *There exists at least one pair of countries  $(i, j)$  such that  $\text{sign}(1 + \sum_{l=\beta}^{\theta} \rho_{t_l} \Psi_l - \rho_{t_i} \Psi_i)(\bar{k}_i - k_i) \neq \text{sign}(1 + \sum_{l=\beta}^{\theta} \rho_{t_l} \Psi_l - \rho_{t_j} \Psi_j)(\bar{k}_j - k_j)$ .*

**Proof.** To prove this we first compute  $\Psi_i$  and show that  $1 + \sum_{l=\beta}^{\theta} \rho_{t_l} \Psi_l - \rho_{t_i} \Psi_i$  has the same sign for all countries which is a sufficient condition for the statement of the lemma as  $\bar{k}_i - k_i$  does not have the same sign for all countries.

$$dt_i = \Psi_i(d\underline{\delta} \frac{\partial \rho}{\partial \underline{\delta}} + d\bar{\delta} \frac{\partial \rho}{\partial \bar{\delta}}) = (d\underline{\delta} \sum_{j=1}^{\beta} \lambda_j + d\bar{\delta} \sum_{j=\theta}^N \lambda_j) \Psi_i.$$

with  $\Psi_i = \lambda_i \frac{1}{1 - \sum_{j=\beta}^{\theta} \lambda_j^2}$ .

It is now possible to check if  $1 + \sum_{j=\beta}^{\theta} \rho_{t_j} \Psi_j - \rho_{t_i} \Psi_i$  has the same sign for all countries<sup>8</sup>.

$$1 + \sum_{j=\beta}^{\theta} \rho_{t_j} \Psi_j - \rho_{t_i} \Psi_i = 1 + \frac{1}{1 - \sum_{j=\beta}^{\theta} \lambda_j^2} \sum_{j=\beta}^{\theta} \lambda_j^2 - \frac{1}{1 - \sum_{j=\beta}^{\theta} \lambda_j^2} \lambda_i^2 > 0$$

as  $\sum_{j=\beta}^{\theta} \lambda_j^2 < 1$ . ■

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<sup>8</sup>This is a sufficient condition to ensure that there exist at least one pair of countries  $(i, j)$  such that  $\text{sign}(1 + \sum_{l=\beta}^{\theta} \rho_{t_l} \Psi_l - \rho_{t_i} \Psi_i)(\bar{k}_i - k_i) \neq \text{sign}(1 + \sum_{l=\beta}^{\theta} \rho_{t_l} \Psi_l - \rho_{t_j} \Psi_j)(\bar{k}_j - k_j)$ .

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