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Abstract

We construct a general equilibrium model of a two-country trading block where governments through tax policies attract mobile capital, and provide an imported public consumption good. At Nash equilibrium, when the public good is under-provided, (i) a country with a large GDP, has a large Nash equilibrium income tax rate, (ii) if initially the existing foreign capital in the country is zero or small, then the country with a large population or high individual marginal willingness to pay for the public good has a large Nash equilibrium income tax rate. When the two countries act cooperatively, then for each country, the cooperative optimal income tax rate is positive, and if they are identical then the cooperative income tax rate is greater than the Nash. When the two countries are different, then it is possible that the cooperative income tax rate is less than the Nash.

Keywords: Nash and cooperative income taxes,capital mobility, public goods.

JEL Classification: F21, H21, H41.

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Tax Competition, Capital Mobility and Public Good Provision Within a Trading Block

1. Introduction

Capital mobility, international and interregional, has been one of the most prominent features of the world economy for the past few decades. On the one hand, global and/or interregional integration and liberalization of commodity trade and investment through *e.g.*, GATT, WTO, EU negotiations, have triggered and subsequently intensified the mobility of capital.[1] On the other hand, government (local, regional, national) policies, extensive privatization and deregulation activity have intensified the competition among different jurisdictions in acquiring mobile capital. For example, according to the EC's Ruding Committee Report (1992) there is evidence that tax-based incentives are an important means through which EC countries attempt to influence the location of firms and the pattern of capital mobility.[2] Such differences, however, in tax treatments, along with other factors, can potentially be a source of economic inefficiencies ultimately requiring the harmonization of investment tax and other incentive policies across countries.

A voluminous theoretical literature on capital tax competition among regions, or among countries, has emphasized the role of interregional or international capital mobility, and of taxes on the mobile capital for the efficiency of fiscal policy decisions. An emerging conclusion of this literature is that inefficiencies arise when local or national governments use source-based taxes on the income of mobile capital to finance the provision of public goods, with the objective of maximizing their residents' welfare.[3] That is, inefficiently low tax rates and levels of public good provision, and possible deterioration of local or national welfare may result due to non cooperative tax competition for scarce capital among different jurisdictions (*e.g.,* see Gordon and

[1] In light of the 1992 Single Market Program, intra-Community capital flows exceeded those with non-EC countries for the first time. For example, 75 percent of capital inflows to France originated in other EC countries, while 62 percent of the French capital outflows were destined to EC countries. Likewise, the respective figures for Germany were 56 and 55 percent, for Italy 80 and 68 percent, and for the Netherlands 66 percent both. The only exception to this picture was the UK whose respective figures were 39 and 28 percent (see Thomsen and Woolcock, 1993).

[2] For example, between the years 1985 and 1991, corporate income tax rates were reduced from 45 to 39 percent in Belgium, from 50 to 38 percent in Denmark, from 50 to 34 percents in Ireland, from 49 to 46 percent in Greece, and from 40 to 34 percent in the UK (see Thomsen and Woolcock, 1993).

[3] In broader terms, this practice can be interpreted as the inclusion of internationally mobile capital, by local or national governments, into their property tax base (*e.g.,* see Wilson 1987).

Wilson 1986, Zodrow and Mieszkowski 1986, Wilson 1986).[4] As noted in the relevant literature, the primary reason for this result is that even if capital is inelasticaly supplied locally or globally, its mobility results in an infinitely elastic supply for an individual region or country. As a result, source-based tax distortions in a region or in a country force capital to move to another location where its net marginal revenue product exceeds its opportunity cost to the region. This induces an additional cost to the provision of the public good, and entails a detrimental effect on the residents' welfare in the region or country of origin.[5]

We note two important issues of the above literature on capital tax competition related to the present analysis.[6] First, the analytical context is either that of countries composed of identical regions, or that of a world composed of identical countries. Wilson (1991) considers Nash equilibrium in tax rates between two regions with different numbers of identical residents and different factor (*i.e.*, capital and labor) endowments. In this context, tax competition benefits the residents of the relatively smaller region and harms those in the larger one. Kanbur and Keen (1993) using a partial equilibrium model of two countries and a single taxed good show that at the non cooperative equilibrium, the smaller country charges a smaller tax rate than the larger country, and that differences in size exacerbate the inefficiencies from the non cooperative behaviour.[7] Dhillon *et al* (1999) using a model of two identical jurisdictions differing only in terms of preferences for public goods, and where capital is inter-

[4] Zodrow and Mieszkowski (1986) distinguish between the provision of local public goods or services to consumers, and of local public inputs to firms. They conclude that in the case of providing local public goods, increased use of such distortionary property taxes and less reliance on non-distortionary ones (*e.g.*, head tax) always reduces, globally and at the margin, the provision of such goods. For the case of providing public inputs to private production, the same result emerges so long as the perceived marginal cost of raising the property tax (*i.e.*, an output reduction due to the erosion of the tax base) does not exceed (at the margin equals) the value of additional tax revenue.

[5] In a different but related issue, Hoyt (1991) demonstrates that in a model of tax competition among (TB)s of equal size, an increase in their number leads to a further under-provision of public goods, thereby further lowering utility of residents in all (TB)s.

[6] Other issues that have been addressed, but not relevant to our analysis, include the choice of government expenditure as opposed to tax rates as the strategic variable (e.g., Wildasin 1988, Hoyt 1993), and the availability of a variety of tax instruments as opposed to just a capital income tax rate (e.g., Bucovetsky and Wilson 1991). A related literature examines the taxation of mobile capital within the context of optimum income tax models. For recent contributions in this literature see among others Mintz and Tulkens (1996), and Huber (1999).

[7] A recent extension of this literature on fiscal competition between countries of unequal size is within a framework of imperfect competition by Haufler and Wooton (1999). In a setting of inter-jurisdictional capital mobility, they combine differences in country size and multiple tax instruments with per unit trade costs between the competing jurisdictions. They demonstrate that both tax and tariff competition favour the large country in winning the competition for internationally mobile capital.

jurdictionally mobile show, among other things, that tax coordination may call for a second-best allocation supported by differentiated tax rates.

Second, at least in the public finance literature of tax competition, little attention is paid to the relation between government behavior and actual commodity trade. Instead, it is implicitly assumed that there is an exchange between an aggregate consumption good and mobile capital. Wilson (1987), incorporating interregional commodity trade demonstrates that regional tax competition for mobile capital causes an inefficient distribution of public goods across the region accompanied by an inefficient pattern of commodity trade.

In light of the above realizations, the paper aspires to develop an analytical framework that (i) provides a broader theoretical context, e.g., a general equilibrium framework and asymmetries between countries, (ii) incorporates explicitly the provision of public goods, and (iii) is motivated by a real world context in studying the aforementioned issues of the tax competition literature. In regards to the last point, we envision the context of a trading block (TB), such as the European Union (EU), with mobility of commodities and factors so much within its (TB) as well as between the (TB) --EU-- and the rest of the world. To ensure the analytical tractability of our results, the framework we develop is as follows.

We consider a trading block (TB) consisting of two countries --home and foreign-- with capital mobility and provision of public consumption goods. The mobility of capital between the two countries of the (TB) is free, while the total supply of capital in the (TB) is fixed. That is, mobility of capital within the (TB) is perfectly free, while between the (TB) and the rest of the world is completely restricted.[8] Like the bulk of the literature on capital tax competition, it is assumed that capital is taxed on the basis of the “source” principle, and that repatriated capital earnings are untaxed in the source country of capital. Other factors of production, such as labor, are internationally immobile.[9] Commodity trade within the (TB), and between the (TB) and the rest of the

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[8]Clearly this is an assumption for analytical convenience, since by and large, varying degrees of international capital mobility is what is observed in real world. For example, the mobility of capital is free among members of the EU, e.g., France and Germany, nearly free between the EU and other developed countries, e.g., the US, Japan or Canada, and less free or even restricted between the EU and other countries, e.g., Russia, Brazil, Korea. Here to avoid such analytical complications, we assume for simplicity completely restricted capital mobility between the (TB) and the rest of the world.

[9] Despite that free mobility of labor is one of the prominent features of the EU constitution, by and large, non economic reasons (e.g., cultural, social, personal) render low degree of labor mobility within the EU. On the other hand, the mobility of labor between the EU and other (developed/developing) countries is institutionally

world is assumed free.[10] The analysis provides also for the possibility that the two countries comprising the (TB) are either identical or differ in terms of their produced output, of their social marginal willingness to pay for the public goods, or in terms of their population. Each country --home and foreign-- of the economic (TB) comprises of identical individuals, produces a number of freely traded private goods and imports a public good, which is not produced locally. The government in each country imposes an income tax, and uses the tax revenue to finance the imports of the public good. Within this framework we derive and compare the Nash and cooperative equilibrium optimal income tax rates. We also examine the role of each country's GDP, population, and individual marginal willingness to pay for the public good on the optimal Nash and cooperative equilibrium income tax rates.

2. The Model of the Two-country (TB)

We develop a general equilibrium trade model of a (TB) comprised of two countries --home and foreign--, of capital mobility, and of income taxes and public good provision. Each country comprises of identical individuals, it produces a number of freely traded private goods, and imports a public consumption good which is not produced locally.[11] It is assumed that capital mobility within the (TB) is free, so that the net rate of return to capital is equalized between the home and the foreign country. Both countries of the (TB) are considered small in world commodity markets, so that local policies and capital flows do not affect world commodity prices.

Next we describe the structure of the home country, while the structure of the foreign country is modeled in a similar way. Asterisks denote the variables of the foreign country.

2.1 The Home Country with Income Taxes and Public Good Provision

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fairly restricted. For analytical convenience we assume complete immobility of labor within the (TB) as well as between the (TB) and the rest of the world.

[10] EU commodity trade is completely liberalized amongst its member countries. Commodity trade between the EU and the rest of the world in most products (with the exception of few agricultural ones) is nearly free (i.e., subject to an average of 3.5 percent tariff or duty rates). Moreover, This assumption of internationally freer trade in commodities rather than in factors of production is in accordance with results of the literature on the order of markets liberalization, whereby more often than not liberalization of product markets proceeds that of factor markets.

[11] The assumption that the public good is imported is made for simplicity, since now the unit cost (=unit price) of the public good is constant and is not affected by changes in factor supplies or public good provision.

Consider a small open economy producing private traded goods, and importing a public consumption good (*g*). Since international trade in goods is assumed free, domestic commodity prices equal the world prices. Without loss of generality all prices of private goods are normalized to equal one. Many factors of production such as labor, capital and land are used in the production of the private traded goods. Domestic endowments of factors are fixed, and the domestic supply of all factors, except capital, equals their fixed endowments. The domestic supply of capital (*K*) is variable due to international mobility. Production functions are assumed homogeneous of degree one and strictly concave in all factors.

We assume that the private sector produces competitively the private traded goods. The public sector (government) levies a tax at a rate (ρ) on all factors income. Such tax revenue, as well as revenue from lump-sum taxation (T) are then used to finance the imports (provision) of the public consumption good.

Let $R(K)$ be the maximum value of gross domestic product (GDP), given the domestic supply of capital (*K*). The endowments of the fixed factors and the commodity prices are omitted since they are assumed fixed, and thus they do not affect the comparative statics results. The $R(K)$ function is assumed strictly concave in *K* (*i.e.,* R_{KK} is negative). Its partial derivative with respect to *K* (*i.e.,* R_K) is the marginal revenue product of capital, which in equilibrium equals the domestic rate of return to this factor.

The small open home country comprises of identical individuals. By $E(g,u)$, we denote the country's minimum expenditure required to achieve a level of utility u given the level of public good consumption (g) and the prices of the private goods. Since, domestic relative prices are treated as constant, they are omitted from the minimum expenditure function. Following standard practice of the public finance literature, we call $-E_g (> 0)$ the economy wide "*marginal willingness to pay for the public good*" (*e.g.,* see King, 1986). Furthermore, by appropriate choice of units we assume that, $E_u = 1$, *i.e.*, the marginal utility of income is equal to one.

The country's income-expenditure identity requires that total spending by its residents must equal net income from the production of all traded goods minus net repatriated foreign capital earnings and lump-sum taxes. That is:

$$E(u,g)=(1-\rho)R(K)-(1-\rho)K^{f}R_{K}-T\,, \tag{1}$$

where K^f is the stock of foreign capital existing in the country. We assume that the home country is initially a net capital importer.

We now introduce the home country's government budget constraint. Since the government provides the imported public good, financed through income tax revenue and lump-sum taxes, its budget constraint requires that revenue from such taxes must equal the cost of the public good. That is:

$$\mathrm{g}=\mathrm{T}+\rho\mathrm{R}(\mathrm{K})\,, \tag{2}$$

where for simplicity we assume that the government maintains a balanced budget.[12]

2.2. Equilibrium in the (TB)

We consider a (TB) of two countries, home and foreign, where each uses income taxes to finance the provision of the imported public good. International capital mobility within the (TB) is perfect and it is assumed that initially "home" is net capital importing while "foreign" is the net capital exporting country. Furthermore, it is assumed that the internationally mobile capital is taxed on the basis of the "source" principle, and that the repatriated capital earnings are untaxed in the source country of capital. Equilibrium in the (TB) is characterized by equations (1), (2) and the following conditions:

$$E^{*}(u^{*},g)=(1-\rho^{*})R^{*}(K^{*})+(1-\rho)R_{K}K^{f}-T^{*}, \tag{3}$$

$$\mathrm{g}^{*}=\mathrm{T}^{*}+\rho^{*}\mathrm{R}^{*}(\mathrm{K}^{*})\,, \tag{4}$$

$$(1-\rho)R_{K}(K)-(1-\rho^{*})R_{K}^{*}(K^{*})=0\,, \tag{5}$$

where K^* is the supply of capital in the foreign country. It is assumed that the total capital within the (TB) is fixed, *i.e.*, $\mathrm{K}+\mathrm{K}^{*}=\overline{\mathrm{K}}$, where $\overline{\mathrm{K}}$ is the total stock of capital divided between the two countries in the (TB). Thus, $dK^{*}+dK=0$ and

[12] Note that by construction the unit price of the public good is equal to one (see equations (2) and (4)). Alternatively, it can be assumed that the unit price is a constant (*e.g.*, p_g and p_g^*) other than one. In a model where the public good is locally produced, the unit price equals the unit cost of the public good and becomes a function of, among other things, domestic factor prices (*e.g.*, see Michael and Hatzipanayotou 1998).

$dK^f = dK = -dK^*$. Equation (3) denotes the income-expenditure identity for the foreign country. In this case, total spending by the country's residents must equal net income from the production of private traded goods plus net repatriated capital earnings, minus lump-sum taxes. Equation (4) is the foreign country's government budget constraint, which is also assumed to be balanced. Finally, equation (5) captures the equilibrium in the (TB)'s capital market. It states that since capital is perfectly mobile within the (TB), equilibrium in its capital market requires the equalization of the net rate of return to the factor in the two countries.

We use this framework to examine the effects of income taxes on each country's welfare. We derive and compare, in the presence of international capital mobility and public good provision, the optimal income tax rates when the two countries (governments) choose these tax rates either non cooperatively (*i.e.*, Nash equilibrium income tax rates) or cooperatively. To this end, equations (1) to (5) can be solved in terms of the national levels of social welfare in the two countries (*i.e.*, u and u^*), of public good provision (*i.e.*, g and g^*) and of supply of capital $K(K^*)$. The policy parameters in our analysis are the two income tax rates (*i.e.*, ρ and ρ^*). The Appendix of the paper provides some of these comparative statics results.

3. Income Taxes, International Capital Mobility, and Welfare

Before proceeding to the analysis of the non-cooperative (Nash)/cooperative income tax strategies of the two countries, we derive in this section some benchmark welfare results useful for that analysis to follow. Differentiating equations (1) and (3), we get:

$$(du/d\rho) = -(R - K^f R_K) - E_g(dg/d\rho) - (1-\rho)R_{KK}K^f(dK/d\rho), \text{ and} \tag{6}$$

$$(du^*/d\rho^*) = -R^* - E_g^*(dg^*/d\rho^*) + (1-\rho)R_{KK}K^f(dK/d\rho^*). \tag{7}$$

Equations (6) and (7) indicate that, in the present context, an increase in a country's income tax rate affects its own welfare through three effects. A *direct-effect*, and two indirect ones, of which the first we call the *public-good-effect*, and the second we call the *capital-mobility-effect*.

In equation (6) the first right-hand-side term in parenthesis is the negative *direct-effect* of the higher domestic income tax rate on the country's own welfare. The *public-good-effect*, whose sign is generally ambiguous but positive for a small tax rate, is the effect of the higher income tax rate on the national welfare through changes in government net tax revenue and thus through public good provision.[13] The *capital-mobility-effect* exerts a negative impact on the home country's national welfare. Intuitively, through this term, a higher income tax rate, which induces a capital outflow, increases the marginal revenue product of capital in the home country and thus it increases the payments to foreign capital, affecting negatively the home welfare.

Similarly, equation (7) shows the effect of higher foreign income tax on the foreign capital-exporting country's welfare. The first effect on the right hand side is the negative *direct-effect*, while the second term, *the public-good-effect*, shows the effect on its welfare through changes in the net government revenue and thus public good provision. The last term in this case, *the capital-mobility-effect* indicates that an increase in the labor-exporting country's income tax rate causes a capital outflow, thus capital inflow in the home country, affecting negatively the factor's marginal revenue product in the home country. As a result, repatriated capital earnings to the foreign country are lower, thus affecting negatively its level of welfare.

Using equations (1)-(5) we can rewrite equations (6) and (7) (*i.e.*, $(du/d\rho)$ and $(du^*/d\rho^*)$) explicitly incorporating the changes in public good provision and supply of capital due to changes in each country's own income tax rate. That is:

$$H(du/d\rho) = -HRS_g - \rho E_g R_K^2 + (1-\rho^*)R_{KK}^* K^f R_K, \quad \text{and} \tag{8}$$

$$H(du^*/d\rho^*) = -HR^* S_g^* - \rho^* E_g^* R_k^2 - (1-\rho) R_{KK} K^f R_K^*. \tag{9}$$

where $H = [(1-\rho)R_{KK} + (1-\rho^*)R_{KK}^*] < 0$, and $S_g = (1+E_g)$. The value of S_g is negative (positive) if $|E_g| > (<) 1$. That is, S_g is negative (positive) if in the home net capital-importing country the economy wide marginal willingness to pay for the public

[13] Differentiating equation (2) and applying the result into the expression for $(dg/d\rho)$ from equations (1)-(5) (see the Appendix) we get $(dg/d\rho) = H^{-1}(HR + \rho R_K^2) = H^{-1}[H(\partial B/\partial\rho) - R_K(\partial B/\partial K)]$, where $(\partial B/\partial\rho) = R$ and $(\partial B/\partial K) = -\rho R_K$.

good is greater (smaller) than its marginal cost. In other words, S_g is negative (positive) if in the host country the public good is under (over)-provided. Symmetrically we defined S_g^*, which is negative (positive) if in the foreign capital-exporting country the public good is under (over)-provided.

In equation (8), the first right-hand-side term (*i.e.,* $-RS_g$) indicates that a higher domestic income tax rate affects the home country's welfare positively (negatively) if there is an under (over)-provision of the public good. The second right-hand-side term (*i.e.,* $-H^{-1}E_g\rho R_K^2$) exerts a negative impact on the home country's welfare, while the last term of the equation (*i.e.,* $H(1-\rho^*)R_{KK}^* K^f R_K$) entails a positive impact. Assuming that initially $K^f = 0$ in the home capital-importing country equation (8) reduces to $(du/d\rho) = -RS_g - H^{-1}E_g\rho R_K^2$. Since the second right-hand-side term of this expression is negative, it implies that it is a positive income tax rate that maximizes social welfare. Note that if $S_g > 0$, then unambiguously $(du/d\rho) < 0$, implying that an increase in the home income tax rate unambiguously reduces domestic welfare. This requires that the optimal income policy is a zero tax rate or, if possible a subsidy.[14] Thus, to have a positive optimal income tax rate, when $K^f = 0$, S_g must be negative. For the rest of the analysis, and regardless of the size of K^f we maintain the assumption that $S_g < 0$. On the other hand, in equation (9) the last two right-hand-side terms show negative effects on the foreign country's welfare when its income tax rate increases. If there is also an over-provision of the public good (*i.e.,* $S_g^* > 0$) then unambiguously $(du^*/d\rho^*) < 0$ which requires an optimal income policy of a zero tax rate or, if possible a subsidy. Accordingly, for a positive optimal income tax rate, S_g^* must be negative. This assumption is maintained for the rest of the analysis. Observing equations (8) and (9) and combining the previous analysis, we state the following proposition.

Proposition 1: *Consider a (TB) of two countries with perfect capital mobility between them and where each country imposes an income tax to finance the provision of one*

[14] For a subsidy to be a possible optimal income policy the government has to collect enough tax revenue using lump-sum taxes.

imported, and under-provided public good. Then, for the net capital-importing country the optimum policy is a positive income tax. For the net capital-exporting country it can be an income subsidy if its capital stock located in the other country is large and lump-sum taxes are present. Otherwise its optimal policy is a non-negative income tax.[15]

Using the system of equations (1)-(5), (see the Appendix) we get the effect on each country's welfare when both countries change their income tax rates, as follows:

$$Hdu = Ad\rho + Bd\rho^* \text{ , and} \tag{10}$$

$$Hdu^* = A^* d\rho^* + B^* d\rho \text{ ,} \tag{11}$$

where $A = -HRS_g - E_g \rho R_K^2 + (1-\rho^*) R_{KK}^* K^f R_K$, $B = R_K^* [(1-\rho) K^f R_{KK} + \rho R_K E_g] < 0$,

$A^* = -HR^* S_g^* - \rho^* R_K^{*2} E_g^* - (1-\rho) K^f R_K^* R_{KK}$, $\mathrm{B}^* = \mathrm{R}_\mathrm{K} [\mathrm{E}_\mathrm{g} \rho^* \mathrm{R}_\mathrm{K}^* - (1-\rho^*) \mathrm{R}_{\mathrm{KK}}^* \mathrm{K}^\mathrm{f}]$.

Equation (10) indicates that, other things equal (*i.e.,* $d\rho = 0$), an increase in the foreign country's income tax rate has a positive effect on the home country's national welfare (*i.e.,* $(du / d\rho^*) = H^{-1} B > 0$). On the other hand, other things equal in the foreign country (*i.e.,* $d\rho^* = 0$), an increase in the home country's income tax rate has an ambiguous effect on its level of national welfare (*i.e.,* $(du^* / d\rho) = H^{-1} B^* > 0 (< 0)$).

4. Nash Equilibrium Income Tax Rates

In this section, we derive the Nash (non cooperative) optimal income tax rates for the home and foreign countries, respectively. It is assumed that there is no fiscal or other type of cooperation between the two countries, and that the only interaction between them is that through the (TB)al capital market.

4.1 The Nash Optimal Income Tax Rates

The necessary conditions for each country's optimal choice of its income tax rate, conditional upon the choice of the income tax rate of the other country require the setting of $H(\partial u / \partial \rho) = A = 0$ in equation (10), and of $H(\partial u^* / \partial \rho^*) = A^* = 0$ in equation

[15] With factors of production in fixed endowments, income taxes are equivalent to lump-sum taxes.

(11). In doing so, the corresponding Nash (non cooperative) optimal income tax rates are obtained by solving the following income tax rate reaction functions:

$$A = \rho A_1 + \rho^* A_2 - A_3 = 0 \text{, and} \tag{12}$$

$$A^* = \rho A_2^* + \rho^* A_1^* - A_3^* = 0. \tag{13}$$

where $F = (R_{KK} + R_{KK}^*) < 0$, $A_1 = [RS_g R_{KK} - R_K^2 E_g] > 0$, $A_2 = (RS_g - K^f R_K) R_{KK}^* > 0$ and $A_3 = (RS_g F - K^f R_K R_{KK}^*) > 0$. Similarly, in equation (13) the respective terms are: $A_1^* = [R^* S_g^* R_{KK}^* - R_K^{*2} E_g^*] > 0$, $A_2^* = (R^* S_g^* + K^f R_K^*) R_{KK}$, and $A_3^* = (R^* S_g^* F + K^f R_K^* R_{KK})$. Equations (12) and (13) are solved simultaneously to obtain the optimal Nash equilibrium ρ^N and ρ^{*N} rates as follows:

$$\rho^N = (A_3 A_1^* - A_2 A_3^*)(A_1 A_1^* - A_2 A_2^*)^{-1} =$$
$$(r_0 - RS_g F E_g^* R_K^{*2})\,[r_1 - RS_g R_{KK} E_g^* R_K^{*2} - R_K^2 E_g R^* S_g^* R_{KK}^* + R_K^2 R_K^{*2} E_g E_g^*]^{-1}, \tag{14}$$

$$\rho^{*N} = (A_1 A_3^* - A_3 A_2^*)(A_1 A_1^* - A_2 A_2^*)^{-1} =$$
$$(r_0^* - R^* S_g^* F E_g R_K^2)\,[r_1 - RS_g R_{KK} E_g^* R_K^{*2} - R_K^2 E_g R^* S_g^* R_{KK}^* + R_K^2 R_K^{*2} E_g E_g^*]^{-1}. \tag{15}$$

where $r_0 = K^f R_{KK}^* [R_{KK} (R^* S_g^* R_K - RS_g R_K^*) + R_K R_K^* (E_g^* R_K^* + K^f R_{KK})]$,

$r_1 = K^f R_{KK}^* [R_{KK} (R^* S_g^* R_K - RS_g R_K^*) + K^f R_K R_K^* R_{KK}]$, and

$r_0^* = K^f R_{KK} [R_{KK}^* (R^* S_g^* R_K - RS_g R_K^*) + R_K R_K^* (-E_g R_K + K^f R_{KK}^*)]$.

Note that the signs of r_0 and r_1 depend on the sign of the term $(R^* S_g^* R_K - RS_g R_K^*)$, while the sign of r_0^* depends of the sign of both terms in the parentheses in the right-hand-side brackets.

Equations (12) and (13) give us the implicit income tax reaction functions of the two countries. To get points where each reaction function intersects each axis, we proceed as follows: Setting $\rho^* = 0$ in equations (12) and (13), the corresponding intercept points on the ρ axis are respectively:

$$\rho^0\Big|_{\rho^*=0} = A_3 A_1^{-1} > 0 \quad \text{and} \quad \rho^1\Big|_{\rho^*=0} = A_3^* A_2^{*-1} \tag{16}$$

Similarly, setting $\rho = 0$ in (12) and (13), the corresponding intercept points on the ρ^* axis are respectively:

$$\rho^{*0}\Big|_{\rho=0} = A_3 A_2^{-1} > 0 \quad \text{and} \quad \rho^{*1}\Big|_{\rho=0} = A_3^* A_1^{*-1} \tag{17}$$

Combining equations (16) and (17), we can conclude that the home reaction function has a negative slope while the slope of the reaction function of the foreign country can be positive or negative.[16] Next, we examine few special cases.

Consider first the case where the public good is optimally provided in both countries (*i.e.*, $S_g = S_g^* = 0$) and initially no foreign capital exists in the home country (*i.e.*, $K^f = 0$). In this case the Nash equilibrium income tax rate for each country is zero. Next, we continue to assume that the public good in each country is optimally provided but that foreign capital is already located in the home net capital-importing country (*i.e.*, $K^f > 0$). In this case equation (14) shows that the Nash equilibrium income tax rate for the home country is positive, and less than one if $K^f < -R_K (R_{KK}^*)^{-1}$.[17] On the other hand equation (15) shows that the Nash equilibrium income tax rate of the foreign country has an ambiguous sign and is positive if $K^f > -R_K (R_{KK}^*)^{-1}$. This analysis suggests that when the Nash equilibrium income tax rate for the home country is less than one, then the Nash equilibrium income tax rate for the foreign country is negative (*i.e.*, income subsidy). Thus, in the present model is not possible to have simultaneously

[16] We have not examined the slope of the reaction functions for the full range. If the reaction functions are linear then the slope is definitely negative.

[17] When $K^f > 0$ and $S_g = 0$, equation (14) reduces to $\rho^N = [K^{f2} R_{KK} R_{KK}^* - K^f R_{KK}^* R_K^*][K^{f2} R_{KK} R_{KK}^* + R_K R_K^*]^{-1}$. Setting that $\rho^N < 1$ leads to the above condition.

$0 < \rho^N < 1$ and $\rho^{*N} \geq 0$. In particular, when $0 < \rho^N \leq 1$, then $\rho^{*N} \leq 0$. The reaction functions for this case are shown in Fig.1.

[Figure 1]

The schedules $\rho(\rho^*)$ and $\rho^*(\rho)$ are, respectively, the reaction functions of the home capital-importing, and of the foreign capital-exporting countries. Under the assumption that $S_g = S_g^* = 0$ and $K^f > 0$, the slopes of the two reaction functions, according to equations (12) and (13) are, $(d\rho^* / d\rho) = -(A_1 / A_2) < 0$ for the home country, and $(d\rho^* / d\rho) = -(A_2^* / A_1^*) > 0$ for the foreign. Furthermore, using equations (16) and (17), the points of intersection with the two axes are depicted as $\rho^0 = (A_3 / A_1) > 0$ and $\rho^{*0} = (A_3 / A_2) = 1$ for the home country reaction function, $\rho^{*1} = (A_3^* / A_1^*) < 0$ and $\rho^1 = (A_3^* / A_2^*) = 1$ for the foreign country reaction function. At Nash equilibrium, the point of intersection of the two reaction functions shows that when $0 < \rho_N < 1$ is the optimal income tax rate for the home capital-importing country, $\rho^{*N} < 0$ is the optimal income tax rate for the foreign capital-exporting country.

Second, we examine the case where initially $K^f = 0$, but now the public good is not optimally provided in either country**.** In this case we have that $r_0 = r_1 = r_0^* = 0$. Equations (14) and (15) indicate that the sign of either Nash optimal income tax rate depends on whether the public good is under (over)-provided in that country, *i.e.*, if in the source country $S_g < 0(>)0$, and if in the host country $S_g^* < 0(>0)$. In each country, the optimal income tax rate at Nash equilibrium is positive if there is an under-provision of the public good. Finally, using either equation (14) or (15) it can be shown that if the two countries are identical, in the sense that $R = R^*, E_g = E_g^*, R_K = R_K^*$, then the Nash equilibrium optimal income tax rate is the same -positive and strictly less than one, *i.e.*, $0 < \rho^N < 1$.[18]

When $K^f = 0$, then the terms A_2^* and A_3^* are both positive. In this case the slope of the foreign country's reaction function is negative. Comparing the income tax rates in equations (16) to those in equations (17), it can show that $\rho^{*1} > \rho^{*0}$, and that $\rho^{1} > \rho^{0}$. Similarly, comparing the income tax rates in equations (16) to the Nash optimal income tax rates in equations (14) and (15), [19] can show that $\rho^{N} < \rho^{0}\big|_{\rho^{*}=0}$ and $\rho^{*N} < \rho^{*0}\big|_{\rho=0}$. Thus, the foreign country's income tax reaction function has a negative slope and the home reaction function is steeper than the foreign reaction function. The latter condition guaranties that the Nash equilibrium is stable. The reaction functions in this case are shown in Fig. 2

[Figure 2]

The schedules $\rho(\rho^{*})$ and $\rho^{*}(\rho)$ are, respectively, the reaction functions of the home capital-importing, and of the foreign capital-exporting countries. Under the assumption that $S_g < 0, S_g^{*} < 0$ and $K^{f} = 0$, both reaction functions have a negative slope. Moreover, in this case, as previously discussed, $\left|A_1 / A_2\right| > \left|A_2^{*} / A_1^{*}\right|$. The Nash equilibrium, depicted by the intersection of the two reaction functions, indicates that $\rho^{N} > 0$ and $\rho^{*N} > 0$.

4.2 Nash Tax Rates and the Economy

Next, we examine how the Nash equilibrium income tax rate is affected by the level of the country's GDP and the economy wide marginal willingness to pay for the public good. From equations (12) and (13) we get that $A = 0$ and $A^{*} = 0$ at the Nash equilibrium. Totally differentiating these reaction functions we get that

$$A_{\rho} d\rho + A_{\rho^{*}} d\rho^{*} = -A_{E_g} dE_g - A_{E_g^{*}} dE_g^{*} - A_R dR - A_{R^{*}} dR^{*}, \tag{18}$$

$$A_{\rho}^{*} d\rho + A_{\rho^{*}}^{*} d\rho^{*} = -A_{E_g}^{*} dE_g - A_{E_g^{*}}^{*} dE_g^{*} - A_R^{*} dR - A_{R^{*}}^{*} dR^{*}, \tag{19}$$

Since $A_R^{*} = A_{E_g}^{*} = A_{R^{*}} = A_{E_g^{*}} = 0$, from equations (18) and (19) we get that

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[18] Simple calculations can show that when the two countries are identical, at Nash equilibrium the optimal income tax rate is $0 < \rho^{N} = 1[1 - (R_K^2 E_g / RS_g F)]^{-1} < 1$.

$$\Omega \frac{d\rho^N}{dR} = -A_R A^*_{\rho^*} \ , \qquad (20)$$

$$\Omega \frac{d\rho^N}{dE_g} = -A_{E_g} A^*_{\rho^*} \ , \qquad (21)$$

$$\Omega \frac{d\rho^{*N}}{dR^*} = -A^*_{R^*} A_\rho \ , \qquad (22)$$

$$\Omega \frac{d\rho^{*N}}{dE^*_g} = -A^*_{E^*_g} A_\rho \ , \qquad (23)$$

where $\Omega = \begin{vmatrix} A_\rho & A_{\rho^*} \\ A^*_\rho & A^*_{\rho^*} \end{vmatrix}$. Stability of the Nash equilibrium requires that $\Omega > 0$. Also, notice that $A_\rho > 0$ and $A^*_{\rho^*} > 0$ for the Nash equilibrium income tax rate to maximize welfare of each country.[20] Differentiating A we get $A_R = -HS_g$ which is negative if the public good is under-provided and $A_{E_g} = -HR - \rho R_k^2 = -FR - \rho(R_K^2 - RR_{KK}) + \rho^* RR^*_{KK}$. If $\rho \le (-FR + \rho^* RR^*_{KK})/(R_k^2 - RR_{KK})$, then $A_{E_g} \ge 0$. Similarly, $A^*_{R^*} < 0$ if the public good is under-provided and $A^*_{E^*_g} \ge 0$ if $\rho^* \le (-FR^* + \rho R_{KK} R^*)/(R_K^{*2} - R^*_{KK} R^*)$. Equations (20) and (22) show that an increase in a country's GDP increases its Nash equilibrium income tax rate. Equations (21) and (23) show that an increase in the country's economy wide marginal willingness to pay for the public good increases its Nash equilibrium income tax rate when the initial tax rate is relatively small. In the case where $K^f = 0$, it can be shown that the Nash equilibrium income tax rate is smaller than the income tax rate that makes $A_{E_g} = 0$, and thus an increase in the economy wide

[19] Dividing the terms of (14) by $E^*_g R_K^{*2}$, and those of (15) by $E_g R_K^2$, we obtain the above result.

[20] Rearranging equation (10) we get that $du/d\rho = A/H$. Since $d^2u/d\rho^2 = (A_\rho / H) < 0$ at the Nash equilibrium for maximizing welfare, we get $A_\rho > 0$ since $H < 0$. Similarly, we can show that $A^*_{\rho^*} > 0$.

marginal willingness to pay for the public good increases the Nash equilibrium income tax rate.[21]

Proposition 2: *Consider a (TB) of two countries with perfect international capital mobility where each country imposes an income tax to finance the provision of an imported under-provided public consumption good. An increase in each country's output level, increases its Nash optimal income tax rate. An increase in each country's economy wide consumer marginal willingness to pay for the public good increases its Nash optimal income tax rate if* K^f *is zero or small.*

In the special case where initially $K^f = 0$, by differentiating equations (14) and (15) with respect to the foreign country's economy wide consumer marginal willingness to pay for the public good, and its GDP, we get that

$$[\partial\rho^N / \partial(-E_g^*)] = -[(A_1 A_1^* - A_2 A_2^*)^{-1}]^2 [FE_g S_g RR^* R_K^2 R_K^{*2} R_{KK}^*] < 0\,, \tag{24}$$

$$[\partial\rho^{*N} / \partial(-E_g^*)] = [(A_1 A_1^* - A_2 A_2^*)^{-1}]^2 [FE_g R^* R_K^2 R_K^{*2} (S_g RR_{KK} - E_g R_K^2)] > 0\,, \tag{25}$$

$$(\partial\rho^N / \partial R^*) = -[(A_1 A_1^* - A_2 A_2^*)^{-1}]^2 FE_g E_g^* S_g S_g^* RR_K^2 R_K^{*2} R_{KK}^*] < 0\,, \tag{26}$$

$$(\partial\rho^{*N} / \partial R^*) = [(A_1 A_1^* - A_2 A_2^*)^{-1}]^2 [FE_g E_g^* S_g^* R_K^2 R_K^{*2} (RS_g R_{KK} - E_g R_K^2)] > 0\,. \tag{27}$$

Proposition 3: *Consider a (TB) of two countries with perfect international capital mobility where each country imposes an income tax to finance the provision of an imported under-provided public consumption good, and where initially* K^f*=0. An increase in the country's economy wide consumer marginal willingness to pay for the public good, or an increase in its output level, decreases the Nash optimal income tax rate of the other country.*

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[21] Let M be the denominator of the Nash income tax rate from (14) and $N = (R_K^2 - RR_{KK})$. Then the difference between the Nash tax and the tax that sets $A_{E_g} = 0$ is

$$\frac{1}{MN}[K^f R_{KK}^* R_{KK} R_K (-RR_k R_K^* + R_K^2 R^* S_g + K^f R_K^2 R_K^*) + K^f R_{KK}^* R_K R_K^{*2} E_g^* (R_K^2 - RR_{KK}) - FRE_g R_K^2 R_K^{*2}]$$

For small K^f or $K^f = 0$ this is negative leading to $A_{E_g} < 0$ and an increase in the marginal willingness to pay for the public good leads to an increase in the Nash optimal income tax.

The intuition of these results can be developed as follows. Recall from the discussion of equation (6) that an increase in the income tax rate ρ, entails a negative *direct-effect* on social welfare (*i.e.,* $-(R - K^{f} R_{K})$) and two indirect ones, the *public-good-effect*, and the *capital-mobility-effect* which is zero when $K^{f} = 0$. The *public-good-effect* is positive, at least for a small ρ, (*i.e.,* $-E_{g}(dg/d\rho)$). When $-E_{g}$ is larger, the positive effect becomes bigger and equals the negative ones at a higher income tax rate. As a result, the Nash optimal income tax rate is higher. Similarly, from equation (8) we note that an increase in ρ, given that $S_{g} < 0$, entails two positive effects (*i.e.,* $-RS_{g} > 0$ and $(1-\rho^{*})R^{*}_{KK} K^{f} R_{K}$), and a negative one (*i.e.,* $-H^{-1}E_{g}\rho R_{K}^{2} < 0$) on social welfare. Thus, when R is larger, the positive effect is bigger and equals the negative one at higher income tax rate, thus leading to a higher optimal income tax rate at Nash equilibrium.

From equations (20)-(27) we can conclude that within the present context, other things equal, at Nash equilibrium countries with relatively large GDP or large economy wide marginal willingness to pay for the public good, will have relatively high Nash optimal income tax rates. Note that the economy wide marginal willingness to pay for the public good, is the sum over all individuals of the individual marginal willingness to pay for the public good. If the individual marginal willingness to pay for the public good in the two countries is similar, we expect that large countries with large GDP and population will have high Nash optimal income tax rates and countries with small GDP and population will have small Nash optimal income tax rates.[22] Also, if the levels of GDP and population are similar, then countries with high individual marginal willingness to pay for the public good are expected to have high Nash optimal income tax rates, and countries with small marginal willingness to pay for the public good are expected to have low Nash optimal income tax rates.

5. Cooperative Equilibrium Income Tax Rates

In this section we derive the optimal cooperative income tax rates for the home and foreign countries, respectively. That is, we now assume that aside of their interaction through the (TB)al capital market, the two countries select their income tax rates so that the common (*i.e.*, home and foreign country jointly) social welfare is maximized. Using equations (10)-(13), the corresponding cooperative income tax rates are obtained by solving:[23]

$$(\partial u / \partial \rho) + (\partial u^* / \partial \rho) = 0 \quad \Rightarrow \quad \rho A_1 + \rho^* (A_2 + B_1^*) = (A_3 + B_2^*)\,, \tag{28}$$

$$(\partial u^* / \partial \rho^*) + (\partial u / \partial \rho^*) = 0 \;\Rightarrow\; \rho (A_2^* + B_1) + \rho^* A_1^* = (A_3^* - B_2)\,, \tag{29}$$

where $B_1 = R_K^* (R_K E_g - K^f R_{KK})$, $B_2 = K^f R_K^* R_{KK}$, $B_1^* = R_K (R_K^* E_g + K^f R_{KK}^*)$, and $B_2^* = K^f R_{KK}^*$. Equations (28) and (29) are solved simultaneously to obtain the optimal cooperative equilibrium income tax rates ρ^c and ρ^{*c}, as follows:

$$\begin{aligned}\rho^c &= [A_1^* (A_3 + B_2^*) - (A_3^* - B_2)(A_2 + B_1^*)][A_1 A_1^* - (A_2 + B_1^*)(A_2^* + B_1)]^{-1} = \\ &\qquad E_g^* F R_K^* [E_g^* R_{KK} R_K^* + E_g R_{KK}^* R_K]^{-1},\end{aligned} \tag{30}$$

$$\begin{aligned}\rho^{*c} &= [A_1 (A_3^* - B_2) - (A_3 + B_2^*)(A_2^* + B_1)][A_1 A_1^* - (A_2 + B_1^*)(A_2^* + B_1)]^{-1} = \\ &\qquad E_g F R_K [E_g^* R_{KK} R_K^* + E_g R_{KK}^* R_K]^{-1}.\end{aligned} \tag{31}$$

As equations (30) and (31) indicate, the optimal cooperative income tax rates ρ^c and ρ^{*c} are always positive regardless of whether there is under (over)-provision of the public good, and of whether initially K^f is positive or zero. Straightforward calculations provide some interesting results regarding the above cooperative equilibrium income tax rates. First, for the two optimal income tax rates to be less than one, *i.e.*, $\rho^c < 1$ and $\rho^{*c} < 1$, it is required that $E_g^* R_K^* > E_g R_K$ (from equation (30)), and $E_g^* R_K^* < E_g R_K$ (from equation (31)). Clearly the two conditions are contradictory to each other, implying that the two cooperative equilibrium income tax rates cannot be less than one at the same time. Thus, if $\rho^c < 1$ then it must be that $\rho^{*c} > 1$ and vice

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[22]The result that countries with large population will have large Nash Equilibrium tax rates has also been reached by Wilson (1991, Proposition 2) and by Kanbur and Keen (1993) in a partial equilibrium model with a single taxed good.

[23] We assume that appropriate income transfers take place between the two countries so that also each country individually is, welfare-wise, better off relative to the Nash equilibrium.

versa. Since, however, an income tax rate greater than one is not an acceptable solution, we assume that at the limit income tax rate equal to one. Second, $\rho^c = \rho^{*c} = 1$ when either the two countries are identical, or when there is tax harmonization between them (*i.e.*, the two countries decide on imposing a common tax rate).

Differentiating equations (30) and (31) with respect to the foreign country's economy wide consumer marginal willingness to pay for the public good, we get:

$$[\partial\rho^c / \partial(-E_g^*)] = -[(E_g^* R_K^* R_{KK} + E_g R_K R_{KK}^*)^{-1}]^2 E_g F R_{KK}^* R_K^* R_K > 0\,, \tag{32}$$

$$[\partial\rho *^c / \partial(-E_g^*)] = [(E_g^* R_K^* R_{KK} + E_g R_K R_{KK}^*)^{-1}]^2 E_g F R_{KK} R_K^* R_K < 0\,. \tag{33}$$

Proposition 4: *Consider a (TB) of two countries with perfect international capital mobility, where each country imposes an income tax to finance the provision of an imported public consumption good. An increase in the country's economy wide marginal willingness to pay for the public good decreases its cooperative optimal income tax rate, and increases the* cooperative *income tax rate of the other country. This result holds regardless of whether there is an under (over)-provision of the public good.*

Consider the case where we have two countries with identical individual consumer marginal willingness to pay for the public good, but the one has higher population than the other. Then in this case the country with higher population and thus with the higher economy wide marginal willingness to pay for the public good, has a smaller cooperative optimal income tax rate. That is, the large country has small cooperative optimal income tax rate while the small country has a large one. Alternatively, consider the case where the two countries have identical populations but one has a higher individual marginal willingness to pay for the public good than the other. Then, the latter country has a smaller cooperative income tax rate relative to the other.[24] Moreover, equations (30) and (31) indicate that at the cooperative equilibrium, an exogenous increase in the output level of one country leaves unchanged the optimal income tax rate of both countries (*e.g.*, $(\partial\rho^c / \partial R^*) = (\partial\rho^{*c} / \partial R^*) = 0$).

Thus, other things equal, at cooperative equilibrium countries with higher income tax rates are those with a relatively lower economy wide marginal willingness to pay for the public good, while at the Nash equilibrium, we have the opposite result. Contrary to the case of the optimal income tax rates at Nash equilibrium, the levels of output (income) does not affect directly the size of the optimal income tax rates at cooperative equilibrium.

Finally, it is possible for the Nash equilibrium income tax rate to be higher than the cooperative optimal income tax rate. Consider the case where the public good is optimally provided in both countries (*i.e.*, $E_g + 1 = S_g = S_g^* = 0$). In this case if $K^f = -R_K (R_{KK}^*)^{-1}$, then the Nash optimal income tax rate for the home country equals one. In this case, equation (30) shows that if $R_K > R_K^*$ then the cooperative optimum income tax rate is less than one.

6. Concluding Remarks

In the course of the past few decades, international and interregional capital mobility has played a key role in shaping the economies of most of today's modern states. Governments and policy makers are compelled to actively compete in enacting and creating regional or national economic environments "friendly" in attracting mobile capital, despite possible losses to indigenous capital. Otherwise, it is strongly believed that they risk depriving themselves of the vital technological and managerial skills for the sustained growth of their economies. To this end, amongst other policy measures, regional or national tax competition or tax cooperation has been a salient feature of local, regional or national economic policies in attracting mobile capital.

In this paper, motivated by such realizations, we build a general equilibrium model of a small (TB) consisting of two countries with free trade in goods and with perfect capital mobility within the (TB). No capital mobility exists between the (TB) and the rest of the world. Each country imposes an income tax and with the tax revenue finances the provision of one imported and not locally produced public good. Within this framework, we examine (i) the welfare effects of an increase in the income tax rate

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[24] Dhillon *et al* (1999) consider the case with two identical (in terms of technologies and endowments) jurisdictions, differing only in terms of their preferences for public goods. They show that policy coordination may call for a second-best allocation supported by differentiated tax rates.

in each country, (ii) the Nash equilibrium and (iii) the cooperative equilibrium optimum income tax rates.

When each country takes as given the income tax policy of the other country with no reaction, and assuming that the public good is under-provided, then the optimal income tax rate for the net capital-importer is positive while for the net capital-exporter can be positive or negative depending on whether the latter country's initial capital stock located in the former is large or small.

When both countries behave non-cooperatively (Nash), then the Nash equilibrium income tax rate is generally ambiguous. When the public good is optimally provided, then the Nash equilibrium income tax rate for the net capital importing country is positive while for the net capital exporting can be positive or negative. When the income tax rate for the net capital-importing country is less than one, then for the net capital-exporting can be a subsidy or a zero tax.

In general, a country has a large GDP also has a large Nash equilibrium income tax rate. Similarly, if initially the amount of the foreign capital existing in one country is zero or small, then a country with large consumer marginal willingness to pay for the public good has a large Nash equilibrium income tax rate. When initially foreign capital does not exist in either country, then the Nash equilibrium income tax rate of one country decreases when the GDP or the marginal willingness to pay for the public good of the other country increases. When the two countries are identical then their Nash equilibrium income tax rates are equal and less than one.

When the two countries act cooperatively, then the cooperative optimal income tax rate for each country is positive, and if they are identical then the cooperative income tax rate is greater than the Nash. In the case where the two countries are different, then it is possible that the cooperative income tax rate is less than the Nash optimal tax rate. Finally, the cooperative income tax rate of one country decreases (increases) with an increase in its own (the foreign) marginal willingness to pay for the public good.

Appendix.

Differentiating equations (1) to (5), and assuming that $dT = dT^* = 0$, we get the following system of equations in matrix notation**:**

$$\begin{bmatrix} 1 & 0 & (1-\rho)K^f R_{KK} & E_g & 0 \\ 0 & 1 & -(1-\rho)K^f R_{KK} & 0 & E_g^* \\ 0 & 0 & H & 0 & 0 \\ 0 & 0 & \rho R_K & -1 & 0 \\ 0 & 0 & -\rho^* R_K^* & 0 & -1 \end{bmatrix} \begin{bmatrix} du \\ du^* \\ dK \\ dg \\ dg^* \end{bmatrix} = \begin{bmatrix} -R + R_K K^f \\ -R_K^* K^f \\ R_K \\ -R \\ 0 \end{bmatrix} d\rho + \begin{bmatrix} 0 \\ -R^* \\ -R_K^* \\ 0 \\ -R^* \end{bmatrix} d\rho^*, \quad \text{(A.1)}$$

where $H = [(1-\rho)R_{KK} + (1-\rho^*)R_{KK}^*] < 0$, is the determinant of the coefficient matrix of the endogenous variables.

(I) Effects on home country provision of the public good

$$\mathrm{H}(\mathrm{dg}/\mathrm{d}\rho) = \mathrm{HR} + \rho \mathrm{R}_\mathrm{K}^2$$

$$\mathrm{H}(\mathrm{dg}/\mathrm{d}\rho^*) = -\rho \mathrm{R}_\mathrm{K} \mathrm{R}_\mathrm{K}^*$$

(II) Effects on home country supply of capital

$$\mathrm{H}(\mathrm{dK}/\mathrm{d}\rho) = \mathrm{R}_\mathrm{K}$$

$$\mathrm{H}(\mathrm{dK}/\mathrm{d}\rho^*) = -\mathrm{R}_\mathrm{K}^*$$

Symmetrically we define the effects of national tax policies (i.e., ρ, ρ^*) on the on the foreign country's variables (g^*, K^*).

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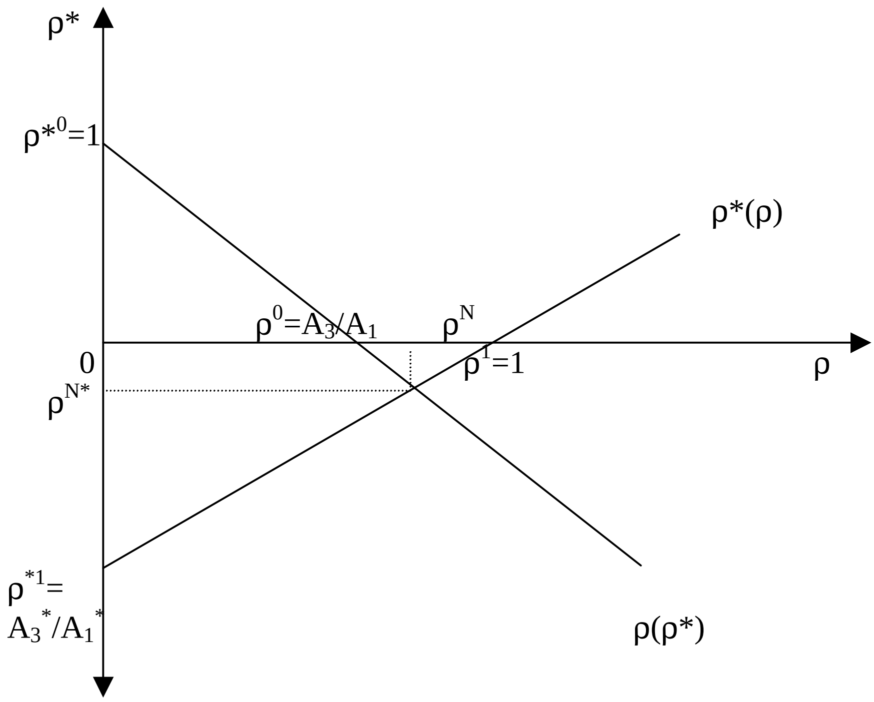

Figure 1: Nash equilibrium when $K^f > 0$, and $S_g = S_g^* = 0$.

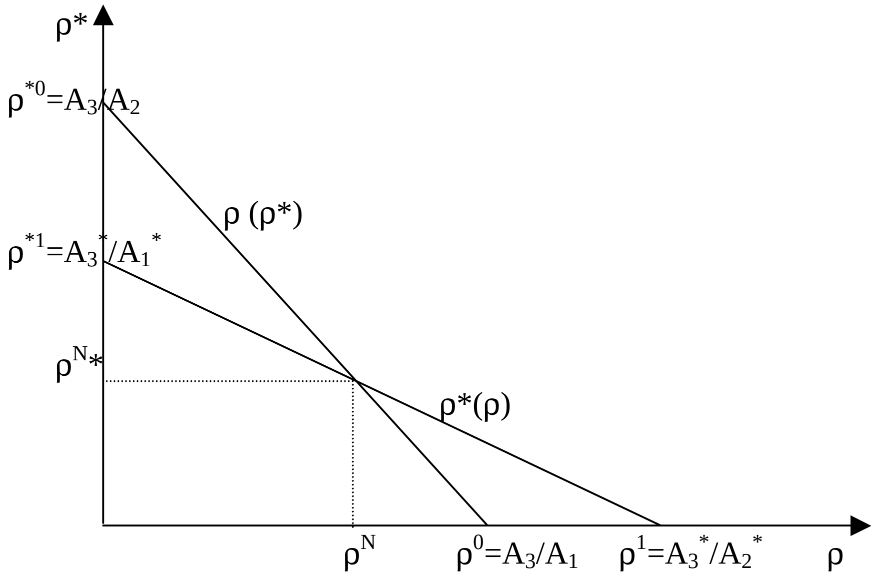

Figure 2: Nash equilibrium when $K^f = 0$, and $S_g < 0$, $S_g^* < 0$