Fiscal Policies and Endogenous Growth

in Integrated Capital Markets

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Abstract

This paper examines the effects of policy coordination in a two-country world with endogenous growth and imperfect capital mobility. Public investment and a public consumption good are financed by a source-based capital-income tax. By comparing the cases in which countries do and do not coordinate their fiscal policies, it follows that spending on investment and redistribution can be inefficiently high if fiscal policies are not coordinated. This is caused by the negative effects of fiscal policy on economic growth abroad. This externality can dominate the well-known tax-base externality. Coordination of only investment policy decreases the inefficiency of that policy, but it increases the inefficiency of noncoordinated provision of the public good.

Keywords: economic integration, capital mobility, (endogenous) growth, tax competition.

JEL codes: H70, F21.

1. Introduction

From the fiscal federalism literature it is well known that decentralized fiscal policies generate externalities in an economic union in which capital is mobile. In general, tax competition often leads to inefficiently low (capital income) tax rates, because countries try to attract capital, and do not take account of the negative welfare effects on other countries.[1] Only if capital harms welfare, e.g. for environmental reasons, the tax on capital could be inefficiently high (Oates and Schwab, 1988).

This paper shows that inefficiently high tax rates can also result if account is taken of the dynamic effects of capital accumulation. The reason is that decentralized fiscal policy affects economic growth abroad negatively. This so called negative growth externality shows up because a domestic source-based capital income tax affects negatively the domestic return on capital in that country, leading to a reduction of wealth accumulation. However, as domestic capital owners invest at home and abroad, the drop in the domestic growth of savings, will also lead to a reduction of investment in the foreign country. This affects in a negative way the foreign growth of production, labour income, etc. Although the noncooperative government takes account of the drop in investment in her own country, she does not take account of these effects abroad. This is the growth externality. So, this externality works in the opposite direction of the traditional tax-base externality and a trade off between these two externalities exists.

Our dynamic model is an endogenous growth model. Recently, the relation between (endogenous) growth, political influence and redistribution has been widely examined within countries.[2] Our model extends the model of Alesina and Rodrik (1991) to a two-country model with imperfect capital mobility. As in their model, we suppose that taxes are levied on capital owners. Tax contributions are used for the production of a public good and for government investment to boost production.

Two-country endogenous growth models are also presented by Devereux and Mansoorian (1992), and Razin and Yuen (1993). Our model deviates from these models substantially. First, we have imperfect capital mobility between the countries and no trade. Second, distinct from most of the literature in the field we model two policy instruments and we also consider the case in which only

[1] See among others Wildasin (1986, 1989), Wilson (1986), and Zodrow and Mieszkowski (1986).
[2] See among others Perotti (1993), Alesina and Rodrik (1994) and Persson and Tabellini (1994).

one of the two policy instruments is coordinated (partial coordination). Third, we examine the consequences of increasing capital mobility on the level of the public good, public investment and economic growth.

Our model compares the case in which the countries determine their own fiscal policy with the case in which a supranational authority determines that policy. It is shown that whether the supply of the public consumption good and the supply of public investment will be inefficiently high (overprovision) or low (underprovision) - depending on the two externalities mentioned before - is determined by the rate of time preference, and the incentives of capital owners to invest abroad. If there is overprovision (underprovision) of public consumption and investment, growth rates will be inefficiently low (high).

We also analyze the case in which the public investment policy is coordinated at a central level, but the decision on the public good is still taken at the national level in a non-coordinated way. Two cases are considered. First, if the central government takes the national decision as given, such a partial coordination of investment policies compared to noncoordinated policies tends to direct the level of public investment in the right direction but too far, while the local supply of the public good will be even more inefficient than in the noncoordinated case due to the distortionary effects of taxation. The rate of economic growth and the tax rate change towards their efficient levels that prevail in the fully coordinated case. Second, if the central authority is a Stackelberg-leader towards the national governments, investment policy turns out to be efficient, while the inefficiency in the supply of the public good will be mitigated compared to the case in which the national policies are taken as given.

Further integration of capital markets will increase the inefficient use of both government instruments if policies are not coordinated or partially coordinated. By lower capital mobility costs, first, capital flows will become more sensitive to differences in fiscal policy, and second, the share of home-owned investment within the country will become lower. If there is underprovision, the former effect dominates. So, countries lower government spending on investment and consumption. If there is overprovision, the latter effect dominates, and induces countries to raise the rate of government spending in the noncoordinated case. These results suggest that coordination of both policies becomes more desirable if capital market integration proceeds.

Section 2 presents the model. Section 3 derives the Nash equilibrium and the reaction curves. Section 4 compares this equilibrium with the case in which government policies are fully centralised and analyses the issue of tax competition. Both cases are compared with the situation in which only public investment policies are centralised in section 5. Section 6 examines the consequences of increasing capital mobility on both policy areas and economic growth. Section 7 concludes.

2. The Model

This section presents the outline of our two-country model that is based on Alesina and Rodrik (1991) and Lejour and Verbon (1996a). The two countries are identical and in each country there are two groups, capitalists and workers. Capitalists pay a source-based tax on capital income, τ.[3] Tax contributions are used for financing the supply of the public good, Z, and public investment, like infrastructure, schooling and the like, G. So, the government's budget constraint reads

$$\tau r K^d = Z + G \qquad K^d = K^s - I + I^* \tag{1}$$

where r represents the return on capital in the home country. Capital that is invested in the home country, K^d, originates from capitalists residing in that country, i.e. their total capital stock, K^s, minus their foreign investment, I, and from investment by foreign capitalists, I^*. The asterisk refers to variables related to the foreign country. For analytical convenience the budget constraint is rewritten as

$$\tau = z + g \qquad z \equiv \frac{Z}{rK^d} \qquad g \equiv \frac{G}{rK^d} \tag{2}$$

z and g represent the ratios of public consumption and public investment to capital income, respectively.

Capitalists posses capital and decide on their amount of investment and its location. Because capitalists are in general less informed about investment opportunities and its risks abroad, they want a higher return on investments abroad to cover this risk. In particular, Persson and Tabellini (1991) and Gordon and Bovenberg (1994) argue that foreign investors have to learn the features of

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[3] This is a short cut for modelling the shift of the tax workers' burden to capitalists in economies in which labour supply is endogenous or the labour market is distorted (e.g. due to wage bargaining), see Alesina and Rodrik (1994) for a more extensive discussion on this issue.

foreign contract law, the tax system, how to deal with foreign banks, the foreign distribution system foreign labour markets, and so on.

We label the extra costs associated with investment abroad as mobility costs, as in Persson and Tabellini (1991). Because there are no diminishing returns on capital in endogenous growth models, mobility costs have to be strictly convex in the amount of investment abroad to guarantee equal after-tax returns on capital in both countries at the margin.[4] This excludes the opportunity that all investment is located in one country.

The assumed convexity of the mobility costs is not in agreement with the fact that a lot of these costs seem to be independent of the amount of foreign investment. However, the mobility costs can also be interpreted in another way. Assume that capital owners are heterogenous, in particular with respect to their risk aversion, capacity to adapt to other circumstances, and that these characteristics are distributed unevenly among all capital owners, such that most of the capital owners have a more than average degree of risk aversion, and less capacity to adapt. Then, first the most flexible, risk-loving capital owners would choose to invest abroad. Later on, more risk-averse, less flexible capital owners would follow. Given that each capital owner has only a limited amount of money to invest, the mobility costs will rise increasingly if more money is invested abroad, because the more risk-averse, less flexible capital owners 'demand' a higher risk premium. They need a larger incentive to invest abroad, so the difference between the after-tax returns on capital in both countries has to be larger.

Total costs of investing abroad is, based on Persson and Tabellini (1991), specified as:

$$M(I/K^s)I \equiv (-\nu + \mu I/K^s)I \tag{3}$$

where $\mu > \nu > 0$ is assumed in order to keep the ratio of wealth invested in the foreign country below one, $I/K^s < 1$. Note, that this specification allows for bidirectional capital flows even if the after-tax returns on capital are equal in both countries, such that $M(\ ) = 0$. The parameter ν represents other possible incentives to invest abroad, except for exploitation of differences in after-tax returns on capital. A decrease in the parameter μ lowers the marginal and total mobility costs, and could be interpreted as a liberalization of capital markets that makes foreign investment more convenient.

[4]This assumption is similar to the stability condition with respect to migration in Stiglitz (1977).

At the margin, the differences in the return on capital between the two countries will equal the mobility costs. The representative capital owner invests in the foreign country until

$$(1-\tau)r \;=\; (1-\tau^{*})r^{*} \;-\; M(I/K^{s}) \tag{4}$$

For foreign capital owners a similar equation exists. Using the definition of K^{d} and equation (3) and (4) for the home country and similar equations for the foreign country we can determine the share of domestic foreign investment in the domestic capital stock as

$$K^{d} \;=\; K^{s}\big(1 \;-\; [(1-\tau^{*})r^{*}-(1-\tau)r^{*}+\nu]/\mu\big) \;+\; K^{s*}[(1-\tau)r-(1-\tau^{*})r^{*}+\nu]/\mu \tag{5}$$

Capital, and government investment serve as inputs in the production function. Endogenous growth requires non-diminishing returns to the economy's reproducible resources at the aggregate level. Following the literature (e.g. Barro and Xala-i-Martin, 1992) we obtain this feature by assuming that output is linear in capital and public investment taken together. This gives the aggregate production function

$$Y \;=\; (K^{d})^{1-\alpha}\,G^{\alpha} \tag{6}$$

Return on capital is determined by profit maximisation, and is equal to

$$r \;=\; \frac{\partial Y}{\partial K^{d}} \qquad \Rightarrow \qquad r \;=\; \big((1-\alpha)g^{\alpha}\big)^{\frac{1}{1-\alpha}} \tag{7}$$

From this equation, it follows that the gross return on capital is positively related to government investment. Residual income will be called wage income which is distributed to the workers. This seems reasonable because most of the government investment consists of investment in human capital. The size of the total labour force is exogenous. Using equation (6) and (7) wage income equals

$$w \;=\; Y \;-\; rK^{d} \;=\; \alpha\,(1-\alpha)^{\frac{\alpha}{1-\alpha}}\,g^{\frac{\alpha}{1-\alpha}}\,K^{d} \tag{8}$$

Wage income, w, depends linearly on the capital stock within the country, and it is positively related to public investment. We suppose that the workers consume their whole wage income, and that no savings from wage income take place.

At the start of the optimization period the existing stock of capital is given, $K^s(0)$. The distribution of this stock over home and foreign investments is determined by the capital mobility condition, equations (3) and (4). From this equation we derive $K(0) - I(0)$, and $I^*(0)$. We assume that the utility function is logarithmic and separable in private and public consumption. The optimisation problem of the representative capitalist reads[5]

$$\max_{C^c} \quad U^c = \int_0^\infty \left(\ln C^c + \delta^c \ln Z \right) e^{-\rho t} dt \tag{9}$$

$$s.t. \quad \dot{K}^s = (1-\tau) r (K^s - I) + \left((1-\tau^*) r^* - M(I/K^s) \right) I - C^c \tag{10}$$

For a complete characterisation of the optimisation problem we have to add the capital mobility condition, equation (4), and the transversality conditions. C^c represents consumption of the representative capital owner residing in the home country. Straightforward maximisation of capitalists' utility implies that the growth rate, π, is equal to

$$\pi(\tau, r) \equiv \frac{\dot{C}^c}{C^c} = (1-\tau) r - \rho \tag{11}$$

Workers' consumption possibilities do not necessarily grow at the same speed as those of capital owners. Workers' income depends linearly on the capital stock within the country. The growth rate of this capital stock is an average of the growth rates of the capital possessed by home and foreign capitalists, weighted by the amount of home and foreign investment within a country. For balanced growth to hold within a country the inward capital flow has to grow at the same rate as the home capital stock. So, there can only be balanced growth within each country if the growth rates of both countries are equal,[6] which we will assume from now on. So, the growth rates will be identical *ex post*. This implies that the growth rates of consumption by capitalists and workers are also equal *ex post*. However, *ex ante* that is not the case. The growth rate of capital invested within a country depends on the growth rates of capital supplied by home and foreign capitalists. As we will see in section 4, this causes the differences between noncoordinated and coordinated fiscal policies.

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[5]For simplicity we assume that capitalists are homogenous. The representative capitalists takes the return on capital and the mobility costs as given in the optimization problem.

[6]If that is not the case, one country would grow faster than the other one. In the end, the country with the lower growth rate would be infinitely small compared to the other country. Razin and Yuen (1993) derive a similar result.

3. The Nash Equilibrium

This section deals with the case in which governments do not coordinate their policies. First, we study the optimum for one country given the foreign policy variables. Second, we analyse the Nash equilibrium. This equilibrium will be compared with the coordinated equilibrium in section 4 and the partially coordinated equilibria in section 5. These comparisons are made in order to examine whether the supply of the public good, and public investment and economic growth are inefficiently low or high in the Nash equilibrium.

The government maximises the sum of intertemporal utility of workers and capitalists. Both groups derive utility from consuming their income and the public good. For simplicity we assume that in each country one worker and one capitalist resides. The optimisation problem of the government reads[7]

$$\underset{g,\ z}{\text{Max}} \quad D = \int_0^\infty \left(\ln(w) + \ln(\rho K^s) + \delta \ln(z r K^d) \right) \exp^{-\rho t} \, dt \tag{12}$$

where ρK^s equals the consumption possibilities of the capitalists in the steady state and $\delta \ln Z$ represents the utility of the public good for both workers and capitalists together. In maximising equation (12) the government takes account of changes in the invested capital stock, K^d, equation (5) and consequently the return on capital and wage income, equation (7) and (8). Moreover, the growth of the (domestic and foreign) capitalist's wealth in the steady state is taken into account. The last variable reads

$$\dot{K}^s = \pi K^s \tag{13}$$

After inserting equations (7) and (8) into (12) the Hamiltonian of this optimization problem apart from a constant is written as follows

$$H^n = \left(\frac{(1+\delta)\,\alpha}{1-\alpha} \ln g + \ln K^s + (1+\delta) \ln K^d + \delta \ln z \right) \exp^{-\rho t} \\ + \lambda \pi(z,g) K^s + \lambda^* \pi^*(z^*, g^*) K^{s*} \tag{14}$$

where λ and λ^* are the positive costate variables. The subscript n refers to the optimization problem in the Nash equilibrium. The necessary conditions for an optimum are given by

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[7]In spite of the open-loop strategies we simply assume that these strategies are time consistent.

$$H_g^n = (1+\delta)\left(\alpha + \frac{(K^s + K^{s*})}{\mu K^d} r(\alpha(1-z)-g)\right)\exp^{-\rho t} + \lambda K^s r(\alpha(1-z)-g) = 0 \tag{15}$$

$$H_z^n = \left(\frac{\delta}{z} - (1+\delta)\frac{(K^s + K^{s*})}{\mu K^d} r\right)\exp^{-\rho t} - \lambda K^s r = 0 \tag{16}$$

$$-H_{K^s}^n = -\frac{1}{K^s}\left(1 + \frac{(1+\delta)(K^s - I)}{K^d}\right)\exp^{-\rho t} - \lambda\pi = \dot{\lambda} \tag{17}$$

Equations (15) and (16) made use of the derivatives $\frac{\partial(1-\tau)r}{\partial g} = \frac{(\alpha(1-z)-g)r}{(1-\alpha)g}$ and $\frac{\partial(1-\tau)r}{\partial\eta} = -r < 0$. Explicit results are derived by substituting equation (15) in (16) to eliminate the costate variable. As a result,

$$z = \frac{\delta(g-\alpha)}{\alpha} \tag{18}$$

So, the supply of the public good is positively related to the supply of public investment. A more explicit solution for the policy instruments can be obtained by using the first-order condition for capital accumulation, equation (17). Differentiating (15) with respect to time and inserting the resulting equation into (17) gives an expression that is used to eliminate the costate variable in (15). If also equation (18) is substituted in (15), we have a closed-form solution for the rate of government investment. Appendix 2 shows this procedure in more detail. The solution reads

$$G(g^n) \equiv (g^n-\alpha)(g^n)^{\frac{\alpha}{1-\alpha}} = \beta\rho\alpha(1-\alpha)^{\frac{1}{\alpha-1}} \quad \text{with} \quad \beta \equiv \left((1+\delta)\mu^{-1}(2\rho+\mu-\nu)+1\right)^{-1} \tag{19}$$

Notice, that because of the assumption $\mu > \nu$, it holds that $\beta > 0$. So, $G(\ )$ is positive. It follows that the rate of government investment exceeds α. This implies that the rate of government investment is higher than the rate that maximises economic growth. The latter follows from $\frac{\partial\pi}{\partial g} = \frac{\partial\pi}{\partial z} = 0$, which reduces to $g = \alpha$ and $z = 0$. This is the familiar result that the rate of investment equals the share of public investment in the production function and that no money is spent on the public good (see among others Alesina and Rodrik (1991), and Barro and Xala-i-Martin (1992)). However, in our problem governments maximise the welfare of workers and capitalists. This differs from maximising economic growth, because, first, wage income is always pushed up by more government investment, while wage income is not taxed and, second, workers and capitalists prefer a public consumption good. This high rate of government spending hurts the capitalists because it lowers their net return on capital in spite of a higher gross return. This implies that $\frac{\partial(1-\tau)r}{\partial g} < 0$.

For the characterisation of the Nash equilibrium, the reactions of the government to changes in the foreign rate of investment, public good and costate variables should be analysed. This is pursued in Appendix 3. The set of first-order conditions consists of 3 equations for each country, (15) to (17). Each set can be reduced to one first-order conditions by substituting (16) and (17) in (15) to eliminate the costate variable and the public good. So, the latter variables are set at their best responses, such that a change in the foreign rate of investment leads to optimal changes of these variables and the home rate of government investment. Using the two modified first-order conditions, it is shown in the appendix that the relation between changes in the rate of government investment at home and abroad is positive. The reaction curves have, thus, a positive slope. Moreover, the slope of the home country's reaction curve is larger than one. Similarly, the slope of the foreign country's reaction curve is smaller than one. This implies that the reaction curves intersect at most once, so there is at most one Nash equilibrium. The optimal values for the rate of government investment and of the public good for both countries (equation (18) and (19)) belongs thus to an unique Nash equilibrium.

4. The Coordinated Equilibrium

As is well known, noncoordinated fiscal policies under the Nash equilibrium are in general not efficient due to the external effects of decision making. In this section we consider the correction of these fiscal externalities by a central authority setting both policy instruments for both countries simultaneously. As the two countries are equal, $\boldsymbol{g} = \boldsymbol{g}^*$ and $z = z^*$ so that the central government can take the growth rates of both countries equal *ex ante*. This implies that $K^{\boldsymbol{d}} = K^s = K^{\boldsymbol{d}*} = K^{s*}$. Maximising welfare for both countries then comes down to maximising the welfare for one (representative) country. The Hamiltonian of this optimization problem apart from a constant reads

$$H^p = \left(\frac{(1+\delta)\,\alpha}{1-\alpha} \ln \boldsymbol{g} + (2+\delta) \ln K^s + \delta \ln z \right) \exp^{-\rho t} + \lambda\, \pi(\eta, \boldsymbol{g}) K^s \tag{20}$$

where λ is the costate variable and the superscript p refers to Pareto-optimal solution. The necessary conditions for an optimum are given by

$$H_g^p \;=\; (1+\delta)\,\alpha\exp^{-\rho t} \;+\; \lambda K^s r(\alpha(1-z)-g) \;=\; 0 \tag{21}$$

$$H_z^p \;=\; \frac{\delta}{z}\exp^{-\rho t} \;-\; \lambda K^s r \;=\; 0 \tag{22}$$

$$-H_{K^s}^p \;=\; -\frac{(2+\delta)}{K^s}\exp^{-\rho t} \;-\; \lambda\pi \;=\; \dot{\lambda} \tag{23}$$

Before solving this system of first-order conditions, we compare this system with the one in the noncoordinated case, equations (15)-(17). These two systems differ in two important ways from each other, that indicate two different external welfare effects. In terms of the growth literature, the first effect is a level effect, and the second one a growth effect.

In the first place, differences consists of the second terms at the right-hand side of equation (15) and (16) which are lacking in (21) and (22). These terms describe the cause of the first externality in the model. It is an external welfare effect on the tax base and gross labour income in the model. Therefore we call it the tax-base externality. Consider a decrease in the size of the public good in the home country. This decrease engenders an increase of the home country's capital stock, which is brought about by a shift in investment from the foreign country to the home country by both home and foreign capitalists. Because of the reduction in the foreign capital stock, the tax base, gross labour income and welfare are reduced abroad. In the noncoordinated case, the decentralized government does not take account of these effects abroad. The central government, however, takes account of both the effect on the foreign and the home capital stock. As a net result, the positive effect on the capital stock in the home country is exactly compensated by the negative effect on that of the foreign country. Therefore the effect on the capital stock does not play a role in equations (21) and (22).

A decrease in government investment instead of the public good does not alter this result. Because the rate of government investment exceeds the rate that maximises economic growth, less government investment raises the net return on capital and economic growth, in spite of the decrease in the gross return on capital. This is due to the fact that all investment is financed by a source-based tax on capital income. So, a change in government investment causes the same qualitative effects as the change in the public good.

In the second place, from comparing equation (23) with (17) it appears that an externality on growth is active.[8] We call this the growth externality. Consider an increase in the public good in the home country. Due to the concomitant increase in the tax rate, the return on capital is lowered in the home country. As a response capitalists in the home country reduce their investment and savings. This reduces the growth of savings. The foreign capitalists also withdraw their investment from the home country but reallocate it to their own country. Because the foreign net return on capital does not change, their net return on savings does not change, so the growth of foreign savings is not affected. However, foreign welfare is affected because the drop in capital accumulation in the home country also implies that home capitalists invest at a lower rate in the foreign country. This reduces the growth of invested capital, the growth of labour income and the tax base in the foreign country. Because the home government neglects the negative effects of more spending on investment and consumption on the foreign country, there is a tendency for too much government spending in the noncoordinated case. The central government takes account of this externality.

The trade-off between the tax-base and growth externality differs from the external welfare effects in Devereux and Mansoorian (1992), who analyse government investment and public good policies in a two-country model with endogenous growth and trade and perfect capital mobility. Consumers derive utility from consuming the two different goods produced in the home and foreign country and from a public good. In their discrete-time model the international spillover effects of fiscal policy operates through three major channels. Increasing home taxes reduce the level and growth of home output. This are two negative welfare effects. The third spillover effect pertains to the growth of foreign output. However, this effect can be negative or positive. If it is negative, it is comparable to the growth externality in our model. Then, government spending is unambiguously excessive, because all three spillover effects work in the same direction. In our model, however, the two distinguished externalities work in the opposite direction.

The system of first-order conditions equation (21) to (23) can be solved in a similar way as in the noncoordinated case. First, combining equations (21) and (22) gives a similar relation between the rate of public consumption and public investment as in the noncoordinated case, see equation (18). Second, the implicit solution for government investment can be obtained by differentiating

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[8] From a more technical point of view, the value of the costate variable is higher in the coordinated case, as can be seen from comparing equation (A2) and (A4) in appendix 1. This implies that growth is relatively more important in the decision function. At the margin, public investment and the public consumption good lower growth. This is a reason to lower public spending in the coordinated case.

equation (21) with respect to time and inserting the resulting expression for $\dot{\lambda}$ into equation (23). This result is used to eliminate the costate variable in equation (21). If this relation is combined with a similar equation as in (18), we have the closed form solution for the rate of government investment.

$$G(g^p) \equiv (g^p - \alpha)(g^p)^{\frac{\alpha}{1-\alpha}} = \frac{\rho\,\alpha\,(1-\alpha)^{\frac{1}{\alpha-1}}}{2+\delta} \tag{24}$$

This equation should be compared with equation (19). It appears that the Pareto-optimal supply of public investment (24) differs from its non-coordinated supply by the parameter $\beta(2+\delta)$. It follows that

$$\beta(2+\delta) \lessgtr 1 \quad \Rightarrow \quad \begin{array}{c} g^p \gtrless g^n \\ z^p \gtrless z^n \end{array} \tag{25}$$

By using the definition of β, $\beta(2+\delta) >(<)\ 1$ corresponds to the condition $2\rho - \nu < (>)\, 0$. The latter inequality can be interpreted in the light of the tax-base and growth externality. From Appendix 3 it appears that the growth externality in the first-order condition for investment can be written explicitly as $\frac{\nu(1+\delta)}{\rho\mu} r(\alpha(1-z) - g)\exp^{-\rho t}$. The tax-base externality, on the other hand equals $-\frac{2(1+\delta)}{\mu} r(\alpha(1-z) - g)\exp^{-\rho t}$ as can be seen from comparing equation (15) and (21). Combining both externalities it follows that if $2\rho - \nu < 0$ (or $\beta(2+\delta) > 1$), the growth externality dominates. In that case, the size of public investment and consumption is inefficiently high in the noncoordinated case.[9]

The inequality $2\rho - \nu < 0$ has an obvious intuition. In the steady state, investment in the foreign country is merely motivated by the non-financial incentive reflected by the parameter ν. So, if this parameter is large the spillovers of too high government expenditures on growth abroad will be large as well.[10] An analogous argument holds if the rate of time preference, ρ, is relatively low. Then, the negative effects of fiscal policy on growth will have more weight in welfare because the future is less heavily discounted. This implies that the growth externality is relatively more important than the tax-base externality is.

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[9]Clarida and Findlay (1994) also conclude that there can be inefficiently much investment by the government caused by policy competition. However, government investment has a direct effect on production in their static model, while here economic growth is affected.

[10]In the extreme case in which $\nu = 0$, capitalists do not have any reason to invest abroad because both countries are identical. So, there is also no spillover effect on foreign economic growth.

The above results on the use of policy instruments can be translated to effects on economic growth. Remember that government investment has a negative effect on economic growth at the margin. Although more government investment raises the gross return on capital, the net return is lowered due to the corresponding increase in the tax rate (balanced budget). So, more government expenditures on investment and redistribution affect economic growth negatively. This implies that if the tax-base externality dominates ($2\rho - \nu > 0$), economic growth in the coordinated case is lower than it is in the noncoordinated case. This result is reversed if the growth externality dominates.

5. Partial Coordinated Government Behaviour

As is well-known from the fiscal federalism literature, coordination is welfare improving if the decentralized governments have only one policy instrument at their disposal. It is not clear, however, whether this result carries over to the case where more policy instruments are used that generates external welfare effects. Coordination in one area could have negative spillovers to the use of policy instruments in other areas. This section considers this issue by examining the effects of investment policies that are determined by a central (supranational) government, while the provision of the public good is still determined by the national governments.

We assume that the central government sets the supply of the public-investment optimally by maximizing equation (20). The national governments, however, retain autonomy on the decision regarding the public good. So, they maximise equation (14) with respect to the public good. They take central decisions as given. For the central government, however, we consider two behaviourial assumptions in turn. First, we consider the case in which the central government acts as a Stackelberg leader towards the national governments by taking account of the relation between its own decision and the national decisions as described by equation (18). Second, we assume that the central government takes the national decisions as given.

We choose here to coordinate investment policies instead of public consumption policies, because to our opinion more efforts take place to coordinate the former policies to some extent than the latter ones, in particular in the European Union. However, coordination of public consumption policies would lead to similar qualitative results as for coordinated investment policies with respect to the coordinated and noncoordinated policy instruments.

The central government as Stackelberg leader

The central government maximises equation (20) with respect to government investment. The first-order condition reads

$$H_g^{pcs} = \frac{(1+\delta)}{g}\frac{\alpha}{1-\alpha}\exp^{-\rho t} + \frac{\lambda K^s}{(1-\alpha)g} r(\alpha(1-z)-g) - \left(\frac{\delta}{z}\exp^{-\rho t} - \lambda K^s r\right)\frac{dz}{dg} = 0 \qquad (26)$$

The superscript pcs refers to partial coordination with the Stackelberg assumption. This implies that the effects of changes in government investment on the public good are taken into account denoted by the derivative $\frac{dz}{dg}$. This derivative is derived from the first-order condition of the national governments with respect to the public good, equation (16), and it equals $-\frac{\alpha}{1-\alpha}\frac{z}{g} < 0$. Equation (23) that describes capital accumulation should be added to equation (26) for the complete set of first-order conditions. If this set is solved, it follows that the supply of public investment will be set at its Pareto optimal level, given by equation (24). The optimal level of the public good provision follows by solving equations (16) and (17). Rewriting this expression using equation (24) gives

$$z^{pcs} = \beta(2+\delta)\delta\frac{(g^{pcs}-\alpha)}{\alpha} = \frac{\beta\rho\delta}{r^{pcs}} \qquad (27)$$

So, the level of the public good provision exceeds the Pareto efficient level in the fully coordinated case, if the growth externality dominates ($\beta(2+\delta) > 1$). This can be seen by comparing this equation with (18). If the tax-base externality dominates, the reverse result holds.

The central government and the Nash strategy

In this case a central government simply maximises equation (20) with respect to government investment, and takes the provision of the public good as given. This gives the first-order conditions (21) and (23). From these two equations we derive public investment as a function of the provision of the public good by eliminating the costate variable. Solving the maximisation problem of the national governments results in a similar relation as before, equations (16) and (17). Combining these results, it follows that

$$G(g^{pcn}) \equiv (g^{pcn}-\alpha)(g^{pcn})^{\frac{\alpha}{1-\alpha}} = \alpha\rho\frac{[(1+\delta) - \delta(2+\delta)\beta]}{2+\delta}(1-\alpha)^{-\frac{\alpha}{1-\alpha}} > 0 \qquad (28)$$

The superscript pcn refers to the case in which the central government takes the decisions on the public good as given. From the comparison of equation (28) with (24) it follows that the rate of

$$z^{pcn} \;=\; \frac{\delta\,(2+\delta)\,\beta}{[(1+\delta)\;-\;\delta\,(2+\delta)\,\beta\,]}\,\frac{g^{pcn}-\alpha}{\alpha} \;=\; \frac{\delta\,\beta\,\rho}{r^{pcn}} \;>\; 0 \tag{29}$$

investment exceeds the Pareto efficient level if the tax base externality dominates ($\beta\,(2+\delta)\,<\,1$) and the reverse result holds if this externality is dominated by the growth externality. Because the provision of the public good is inversely related to the gross return on capital, see equation (27) and (29), it follows quite easily that, if the tax-base externality dominates, less of the public good is provided in the case in which the central government takes the national decisions is given than in the case in which she act as a Stackelberg leader. This is due to the fact that in the latter case the central government realises that the national governments will lower the level of the public good as response to an increase in government investment to lessen the distortionary effects of taxation. Therefore, the increase in government investment and the decrease in public consumption are less pronounced if the central government acts like a Stackelberg leader than if she takes the national policies as given. A similar result holds if the growth externality dominates.

A full ranking of the values of the policy variables, tax rates, and growth rates read

$$\beta\,(2+\delta)\;\lessgtr\;1 \quad\Rightarrow\quad \begin{array}{c} g^{pcn} \lessgtr g^{pcs} \;=\; g^{p} \gtrless g^{n} \\ z^{p} \gtrless z^{n} \gtrless z^{pcs} \gtrless z^{pcn} \end{array} \tag{30}$$

$$\beta\,(2+\delta)\;\lessgtr\;1 \quad\Rightarrow\quad \begin{array}{c} \tau^{p} \gtrless \tau^{pcn} \gtrless \tau^{pcs} \gtrless \tau^{n} \\ \pi^{n} \;\substack{<\\<}\; \pi^{pcs} \gtrless \pi^{pcn} \gtrless \pi^{p} \end{array} \tag{31}$$

The inequalities in equation (30) are explained above. The inequalities in equation (31) are derived by expressing the tax rates and growth rates as a function of government investment.[11] This comparison is explained below for the case that the growth externality dominates the tax-base externality, $\beta\,(2+\delta)\,>\,1$.[12]

Starting from the Nash equilibrium, government spending on investment and consumption is inefficiently high. A central government that decides on public investment corrects partly for these

[11]In all these expressions z is eliminated using equations (18), (27) and (29) for the relevant case.

[12]A similar line of reasoning is valid if the tax-base externality dominates, although all results are reversed.

inefficiencies. If that government behaves as a Stackelberg leader, investment policy is efficient, but the public good provision is raised slightly. As a result, the tax rate is lower than it is in the Nash equilibrium, and economic growth is higher, because the reduction in investment implies that the negative effects of investment on the net return on capital are reduced. If the central government takes the public good provision as given, public investment is lowered to a larger extent. This extra reduction in investment expenditures exceeds the increase in public-good expenditures compared to the case in which the government is a Stackelberg leader. So, the tax rate is lower, and economic growth is higher. In case the central government determines both policies, the inefficiencies of both policies are eliminated. Spending on the public good is reduced compared to the previous cases, which implies that the tax rate is lowered and economic growth is higher than before.

6. A Reduction of Capital Barriers

This section studies the consequences of further integration of capital markets in the economic union by a reduction of the costs of investing abroad, represented by a decrease in the mobility-costs parameter, μ. The reduction in costs is assumed to be given. We analyse the effects on the rate of public investment and public consumption if government policies are determined in a noncoordinated and partially coordinated way. We compare these results with those if policies are fully coordinated.

The effects of lower mobility costs are derived by differentiating the values of the rate of investment and the public good in the Nash equilibrium, see equation (18), and (19), with respect to μ. As a result,

$$\frac{\partial G(g^n)}{\partial g^n}\frac{\partial g^n}{\partial \mu} = \frac{(2\rho-\nu)(1+\delta)\,G(g^n)}{\beta\,\mu^2} \gtrless 0 \quad \text{if} \quad \beta\,(2\delta+1) \lessgtr 1$$

$$\frac{\partial G(g)}{\partial g} = \frac{\alpha\,G(g)}{(1-\alpha)\,g} > 0 \tag{32}$$

$$\frac{\partial z^n}{\partial \mu} = \frac{\delta}{\alpha}\frac{\partial g^n}{\partial \mu} \gtrless 0 \quad \text{if} \quad \beta\,(2+\delta) \lessgtr 1 \tag{33}$$

Equation (32) shows that the effects of lower mobility costs depend on the dominance of the growth or tax-base externality. This is not surprising if we consider the expressions of these external effects in section 4. From equation (4) and (5) it follows that a lower value of μ increases the ratio of foreign investment to total investment. On the one hand, this increase in foreign investment, does increase the tax base externality. Capital is more sensitive to changes in fiscal policy. This is a reason to lower government spending. Then, taxes are lower and the net return on capital is increased. So, if the tax-base externality dominates ($\beta\,(2+\delta) < 1$), equation (32) and (33) have a negative sign.

On the other hand, the increase in foreign investment lowers the ratio of home investment to total investment. This implies that governments take less account of growth in setting their policies, because they are only interested in wealth accumulation of the capitalists residing in their own country to the extent that they can influence it by the source-based tax. Because economic growth is less important for that reason, and growth is negatively affected by higher tax rates, the governments have the incentive to raise the tax rate compared to the case in which marginal mobility costs are higher. This reduces economic growth not only in the home country but also abroad. So, if the growth externality dominates ($\beta\,(2+\delta) > 1$), government spending on investment and the public good are increased, see equations (32) and (33).

A centralized government that determines all fiscal policies internalizes all the mentioned external effects. She is indifferent to the allocation of investment between the two countries and because lower marginal mobility costs does not affect savings, the marginal mobility costs are not relevant in her decision problem. Therefore lower mobility costs do not affect the policy outcomes: the size of government investment and of the public good do not change. The above results in the Nash-equilibrium thus imply that these policies become more inefficient if market integration proceeds[13]. This follows also from the analysis of the external effects. These effects increase due to a decrease in μ. In particular, if the national governments spend inefficiently much on investment and consumption, they raise these expenditures if capital market integration proceeds. This exerts an downward pressure on the rate of economic growth, increasing the difference in economic growth between noncoordinated and coordinated policy. An analogous reasoning is valid if government spending is inefficiently low.

If the central government only decides on investment policies, a reduction in the mobility costs has a similar effects as in the noncoordinated case. First, we consider the case in which the central government acts as a Stackelberg leader. Then, the value of government investment is similar as in the fully coordinated case (see section 5). So, lower mobility costs do not affect centralized investment policy. However, the national spending on the public good is affected. If equation (27) is differentiated with respect to μ it follows that spending is increased if it was already inefficiently high, while it is reduced if it was inefficiently low. This is the same qualitative result as in the noncoordinated case.

This result also holds if the central government takes the national policies as given. Investment policy is then also affected. From examining equation (28) that describes government investment, it follows that lower mobility costs do increase government investment if it was already inefficiently high. The opposite result holds if the size of government investment is inefficiently low. These results depend on the dominance of one of the two external welfare effects in a similar way as in the noncoordinated case.

From the analysis of lower mobility costs in all four cases, we can conclude that lower mobility costs do increase the inefficiency of government spending on investment and consumption if spending was already inefficient. This implies that the desirability of policy coordination does increase even if investment policy is already determined by a central government.

[13]See Lejour (1995) for a related result.

7. Conclusions

This paper combines the standard literature on tax competition - that deals mostly with static models in which capital is mobile between the regions - and the literature on endogenous growth. We develop a two-country model with imperfectly integrated capital markets in which capital in each country is taxed at the source. Tax contributions in each country are used to finance public goods and investment to stimulate production. In each country there are two groups; workers and capital owners. The latter ones have the possibility to invest their wealth at home and abroad. The national government maximises the sum of intertemporal utility of both groups.

First, we consider the Nash equilibrium. It is proved that the equilibrium is unique and that the reaction curves are upward sloping. Interestingly, it appeared that government spending is so large that it lowers the net return on capital. This Nash equilibrium is compared with the one that results if a central government coordinates both policies. The central government takes account of two external welfare effects. First, fiscal policy affects the foreign tax base by the change in the capital stock, and thereby foreign labour income. Second, fiscal policy affects economic growth abroad by the growth of the capital stock that is invested in the foreign country. Because both external effects work in opposite directions it is not clear whether government spending on investment and the public good is over- or underprovided. The paper shows that if the rate of time preference is low (so workers consider the future as important) and there is relatively much foreign investment, the growth externality dominates. Then, there is inefficiently much government spending in both policy areas, and economic growth is inefficiently low. Otherwise, the tax-base externality dominates. Then, government spending is inefficiently low, and economic growth is inefficiently high.

The external effects can be partially solved if one of the policies, in particular investment policy is determined by the central government. If this central government behaves as a Stackelberg leader to the national governments that determine the public good, government investment is efficient as in the coordinated case. Decentralized provision of the public good is still inefficient high or low depending on the dominance of one of the two external welfare effects. If the central government takes the national policies as given, she does not take account of the national responses to her investment policy. The size of government investment is changed in the direction of the efficient level, but it even exceeds the efficient level, because the provision of the public good changes in the opposite direction to correct for the change in distortionary effects of taxation. So, the inefficient size of the public good differs more from the efficient solution than it does in the Nash equilibrium. The tax rate does change in the direction of the efficient level. We have a similar result for the rate of economic growth.

The effects of the increasing integration of the capital markets on fiscal policy are closely connected to the inefficient provision of public consumption and public investment. If the externality on the foreign tax base dominates, countries have an incentive to lower government spending in both areas, while government spending is raised if the externality on foreign economic growth dominates. Because fiscal policy does not change due to economic integration if these policies are coordinated, this implies that the inefficiency of fiscal policy will increase irrespective of the fact whether there is over- or underprovision. If only investment policies are coordinated, the inefficient use of the policy instruments does also increase, except for investment in the Stackelberg case. Proceeding economic integration, thus, increases the desirability of full coordination.

The results of this paper stress the importance of the role of economic growth in evaluating tax competition and the provision of public goods. The model has some limitations in the sense that it is only possible to analyse this issue with identical countries and identical growth rates to guarantee balanced growth, and is therefore not suitable to study structural differences between countries. It is, however, a useful instrument to study the consequences of policy competition in the long term if countries do not differ too much.

The introduction of endogenous growth to the standard fiscal federalism models will also affect the results if fiscal policies are financed by a residence-based tax on capital income. One often concludes that residence-based taxes on capital income solve the problems of tax competition. Also in this model the tax-base externality induced by noncoordinated redistributive policy will vanish, because taxes do not affect locational choices now. However, taxes still affect savings decisions, and thereby economic growth abroad. In addition, countries will compete in attracting capital by raising government investment. Because investment is financed by a residence-based tax, government investment affects the rate of return on capital positively now. From the combination of both externalities it follows that public goods and public investment are overprovided. Based on this reasoning, source-based taxes on capital income seems to be preferable to residence-based taxes because they offset (partially) the overprovision of government spending by the tax-base externality. Lejour and Verbon (1996b) derive a similar result in a two-country model with neoclassical growth.

References

Alesina, A., and D. Rodrik. (1991). "Distributive Politics and Economic Growth," *CEPR Discussion Paper 565*.

Alesina, A., and D. Rodrik. (1994), "Distributive Politics and Economic Growth," *Quarterly Journal of Economics 104*, 465-490.

Barro, R.J., and X. Xala-i-Martin. (1992). "Public Finance in Models of Economic Growth", *Review of Economic Studies 59*, 645-661.

Clarida R., and R. Findlay. (1994), "After Maastricht: Public Investment, Economic Integration and International Capital Mobility," *Economica 60*, 319-329.

Devereux, M.B., and A. Mansoorian. (1992). "International Fiscal Policy Coordination and Economic Growth," *International Economic Review 33*, 249-268.

Gordon, R.H., and L.A. Bovenberg. (1994). "Why is Capital so Immobile Internationally?: Possible Explanations and Implications for Capital Income Taxation," *CentER Discussion Paper 9463*.

Lejour, A. (1995). "Cooperative and Competitive Policies: the European Siamese Twin?," *CentER Discussion Paper 9520*.

Lejour, A.M., and H.A.A. and Verbon. (1996a). "Wage Bargaining, Capital Mobility and Social Insurance Policies in an Economic Union," *forthcoming International Tax and Public Finance 3*.

Lejour, A.M., and H.A.A. Verbon. (1996b). "Source based Taxes versus Residence-based Taxes in a Dynamic Model," mimeo.

Oates, W.E., and R.M. Schwab. (1988), "Economic Competition among Jurisdictions: Efficiency Enhancing or Distorting Inducing?," *Journal of Public Economics 35*, 333-354.

Perotti, R.. (1993). "Political Equilibrium, Income Distribution and Growth," *Review of Economic Studies 60*, 755-776.

Persson, T., and G. Tabellini. (1991). "The Politics of 1992: Fiscal Policy and European Integration," *CEPR Discussion Paper 501*.

Persson, T., and G. Tabellini. (1994). "Is Inequality harmful for Growth?," *American Economic Review 84*, 600-621.

Razin, A., and C-W. Yuen. (1993). "Convergence in Growth Rates: the Role of Capital Mobility and International Taxation," *CEPR Discussion Paper 760*.

Stiglitz, J.E.. (1977). "The Theory of Local Public Goods," In M.S. Feldstein, and R.P. Inman (eds.), *The Economics of Public Services*, proceedings of a conference of the International Economic Association at Turin.

Wildasin, D.E.. (1986). *Urban Public Finance*, Harwood Academic Publishers, Chur.

Wildasin, D.E.. (1989). "Interjurisdictional Capital Mobility: Fiscal Externality and a Corrective Subsidy," *Journal of Urban Economics 25*, 193-212.

Wilson, J.D.. (1986). "A Theory of Interregional Tax Competition," *Journal of Urban Economics 19*, 296-315.

Zodrow, G.R., and P. Mieszkowski. (1986) "Pigou, Tiebout, Property Taxation, and the Underprovision of Local Public Goods," *Journal of Urban Economics 19*, 356-370.

Appendix 1: The solution of the optimization problem in section 3

This appendix describes the method to solve the systems of first-order equations that follows from the optimization problems if the government does not coordinate and does coordinate its policies. The system of three first-order conditions, equation (15) to (17), is solved in the following way. First, we differentiate equation (15) with respect to time. Rearranging the resulting expression using equation (17) gives

$$K^s\lambda\left(\rho + \frac{\dot{\lambda}}{\lambda} + \pi\right) + \frac{(1+\delta)}{\mu}\exp^{-\rho t}\frac{(K^s I^* - K^s(K^s - I))}{(K^d)^2}(\pi - \pi^*) = 0 \tag{A1}$$

Substitute equation (17) in the expression above to eliminate $\dot{\lambda}$, it follows that

$$\lambda = \frac{\exp^{-\rho t}}{\rho K^s}\left(1 + (1+\delta)\frac{(K^s - I)}{K^d} - \left(\frac{K^s I^* - K^{s*}(K^s - I)}{\mu\,(K^d)^2}\right)(\pi - \pi^*)\right) \tag{A2}$$

Ex post the costate variable is much simpler because $\pi = \pi^*$. The costate variable in equation (15) is eliminated by substituting (A2). So,

$$\alpha(1+\delta) + r(\alpha(1-z) - g)\frac{(1+\delta)}{\rho}\left(\rho\frac{(K^s + K^{s*})}{\mu K^d} + \frac{(K^s - I)}{K^d} + \frac{1}{1+\delta} - \frac{(K^s I^* - K^{s*}(K^s - I))}{\mu\,(K^d)^2}(\pi - \pi^*)\right) = 0 \tag{A3}$$

If equation (18) is substituted in (A3), and knowing that $K^s = K^{s*} = K^d$ and $\pi = \pi^*$, equation (19) follows immediately.

The system of the three first-order conditions in section 4, equation (21) to (23), is solved in a similar way. Equation (21) is differentiated with respect to time and simplified using equation (21). This equation is substituted in equation (23) to eliminate $\dot{\lambda}$. This equation is substituted in (21) to eliminate the costate variable and equation (18) is substituted to eliminate the public good. Then, we get the result in equation (24). The value of the costate variable is

$$\lambda = \frac{(2+\delta)\exp^{-\rho t}}{\rho K^s} \tag{A4}$$

Notice that the value of the costate variable in the coordinated case exceeds the one in the noncoordinated case by the term $K^d/(K^s - I)$.

Appendix 2: The slopes of the reaction curves

This appendix analyses the slopes of the reaction curves in the Nash equilibrium. This slope can be expressed in the changes in the rate of investment of both countries. Equation (A3) presents already the first-order condition that contains the rate of public investment and the public good and capital as endogenous variables. Equation (18) is used to eliminate the public good. Then, it follows that $\alpha(1-z) - g = (g-\alpha)(1+\delta)$ and $\pi(g) = (1-\tau)r - \rho = \left(1 - g\delta(g-\alpha)\alpha^{-1}\right)r - \rho$. So, $\frac{\partial(\alpha - g)r}{\partial g} = \frac{(\alpha^2 - g)r}{(1-\alpha)g} < 0$ and $\frac{\partial\pi}{\partial g} = \frac{\partial(1-\tau)r}{\partial g} = \frac{r(\delta(\alpha^2 - g) + \alpha(\alpha - g))}{\alpha(1-\alpha)g} < 0$. The endogenous capital stocks are eliminated using $K^s = K^s(0)\exp^{\pi}$, so $\frac{\partial K^s}{\partial g} = K^s\frac{\partial\pi}{\partial g} < 0$, $\frac{\partial K^d}{\partial g} = (K^s - I)\frac{\partial\pi}{\partial g} < 0$ and $\frac{\partial K^d}{\partial g^*} = I^*\frac{\partial\pi^*}{\partial g^*} < 0$. If these substitutions are carried out, equation (A3) is differentiated with respect to home and foreign public investment to derive the slopes of the reaction curves. It follows that

$$-\frac{(1+\delta)\alpha}{r(\alpha(1-z)-g)}\frac{\partial(r(\alpha(1-z)-g))}{\partial g}dg \;+\; (1+\delta)\frac{r(\alpha(1-z)-g)}{K^s(K^d)^2}\left(\frac{K^s(2I-K^s)}{\mu}+\frac{(K^s-I)I}{\rho}\right)\left(\frac{\partial K^s}{\partial g}dg-\frac{\partial K^{s*}}{\partial g^*}dg^*\right) \tag{A5}$$
$$-\; r(\alpha(1-z)-g)\frac{(1+\delta)}{\rho\,\mu\,(K^d)^2}\left[\frac{\rho}{\mu}(K^s+K^{s*})^2\right]\left(\frac{\partial\pi}{\partial g}dg-\frac{\partial\pi^*}{\partial g^*}dg^*\right) \;=\; 0$$

The terms are explained below. The first term on the first row follows by differentiating $(\alpha(1-z)-g)r$ with respect to g and substituting equation (A3) to get rid of the expression in brackets. As a result, the term preceding dg has a negative sign. The second term on the first row follows by differentiating K^s, K^{s*} with respect to home and foreign investment. Assuming that the term is brackets is negative (this implies at least that foreign investment does not exceed the half of total investment), the term is negative for home investment and positive for foreign investment. The term on the second row follows by differentiatingK^d except for the including term k^S and $\pi,\ \pi^8$ with respect to the investment variables. The big terms in brackets has a negative sign, so the term preceding dg is negative while it is positive for dg^*.

Combining all these terms the total expression preceding dg is negative and preceding dg^* positive if $3\nu < \mu$. So, the relation between changes in the rate of government investment at home and abroad is, thus, positive. The reaction curves have a positive slope. Moreover, the expression preceding dg^A is larger than the one preceding dg^B. This implies that the slope of the home country's reaction curve is larger than one. Similarly, the slope of the foreign country's reaction curve is smaller than one.

Note that the results above also hold if the sign of the second term on the first row is reversed. It isw dominated by the term on the second row. So, the term preceding dg has a negative sign and precedingdg^* a positive sign.

Appendix 3: The relation between the two externalities and $\beta(2+\delta)$ >/< 1

Using the values of the costate variables, the relation between the tax-base and growth externality and the term $\beta \equiv \left((1+\delta)\mu^{-1}(2\rho+\mu-\nu) + 1\right)^{-1} \gtreqless (2+\delta)^{-1}$ is quite simple. First, substitute the value of the costate variable in the noncoordinated case in the first-order condition with respect to investment in the coordinated case, equation (21). Evaluate this equation for the values of the endogenous variables in the noncoordinated case. As a result, equation (21) consists of the following term that represents the combination of the growth and the tax-base externality. It equals

$$\left(\frac{I}{\rho K^d}-\frac{2}{\mu}\right)(1+\delta)\,r(\alpha(1-z)-g)\exp^{-\rho t} \tag{A6}$$

With the help of the capital mobility equation, equation (4), it follows that $I/K^d = \nu/\mu$. Thus, the sign of equation (A6) depends on the sign of $\nu-2\rho$. This is similar to the condition that $\beta(2+\delta) \gtreqless 1$. Note, that we could derive the same result using equation (22).