WP/04/91

IMF Working Paper

Capital Income Taxation and Economic Growth in Open Economies

Geremia Palomba

INTERNATIONAL MONETARY FUND

 WP/04/91

IMF Working Paper

Fiscal Affairs Department

Capital Income Taxation and Economic Growth in Open Economies

Prepared by Geremia Palomba*

Authorized for distribution by Michael Keen

May 2004

Abstract

Do reductions in capital income taxes attract foreign capital and, at the same time, foster economic growth? This paper examines the effect of capital income taxation on the international allocation of capital and on economic growth in a two-country overlapping generations model with endogenous growth and internationally mobile capital. It shows that domestic capital taxes affect both the international allocation of capital and the rate of economic growth and that these two effects are not necessarily the same. A country can increase its share of the existing world capital by changing its taxes but, depending on the elasticity of saving to after-tax returns, this may reduce the rate of capital accumulation and economic growth.

JEL Classification Numbers: F2, H2, O4

Keywords: Open economies, endogenous growth, capital income taxation

Author's E-Mail Address: gpalomba@imf.org

---

* The author wishes to thank Tony Atkinson and Michael Keen for their advice and comments.

Contents Page

I. INTRODUCTION

In many countries, reductions in capital income taxes are used as a means of attracting foreign capital and fostering economic growth. In the European Union, for example, many countries have reduced capital income taxes. In the United States, there has recently been considerable debate about the need to cut corporate taxation. However, despite the link between domestic taxation of capital and international accumulation, limited attention has been given to examining how domestic tax reforms may differently affect the international allocation of capital and its accumulation in an integrated world. The distinction is important. If a reduction in capital income taxes fosters accumulation, then we need to know whether it increases the level of capital or whether it increases the rate of capital accumulation. The numerical measure of the supposed advantage may be different. Unfortunately, the theoretical analysis of international taxation usually relies on short-period models that focus on the effect of domestic taxes on the international allocation of a given stock of capital and ignore long-term accumulation (e.g., Gordon, 1983; Zodrow and Mieszkowski, 1986; Razin and Sadka, 1991; Wildasin 1991; Wilson 1986, 1991; and Bucovetsky and Wilson, 1991). Models that consider accumulation typically limit the analysis to the case of small economies (e.g., Razin and Yuen, 1993, 1999; Turnovsky, 1996; and Asea and Turnovsky, 1998) or to economies with no economic growth (e.g. Bovenberg 1986; Sibert, 1990; Ghosh 1991; and Ha and Sibert, 1997). Thus, the question remains: can tax reductions attract foreign capital and, at the same time, foster capital accumulation, as is often claimed?

The aim of this paper is to examine the international effects of domestic taxation of capital on the international allocation of capital and on accumulation in an integrated world with large economies. The analysis is conducted in terms of a two-country model of endogenous growth where capital is internationally mobile and tax decisions in one country affect the growth process in the other. In so doing, the approach taken here differs in several respects from that in previous contributions. First, the international effects of domestic taxes are examined by focusing on the intertemporal implications on accumulation and growth and not simply on the cross-country allocation of a given stock of capital. Second, explicit account is taken of the interdependence between capital mobility and growth. It is often recognized that mobility of physical capital implies transfers of technology and knowledge across countries, so that technology spills over from one country to others (Bernstein and Mohnen, 1998; and Bayoumi, Coe, and Helpman, 1999). However, progress in formulating models of economic growth with international spillovers in technology has been limited. The model presented in this paper captures these international links by extending a typical learning-by-doing model to the case of open economies (Bertola, 1993).

The basic model of growth is formally set up in the next section. This is a two-country Samuelson-Diamond type of model with overlapping generations as in Buiter (1981), but it incorporates, in addition, the public sector and economic growth. These aspects have been treated by Razin and Yuen (1996) and Lejour and Verbon (1997) in the context of infinite-life-agent models. In these models, however, time preferences limit cross-country tax dependences with the effect that the Euler equation predicts a stable long-run positive relation between the net-of-tax interest rate and economic growth. As a result, increases in taxation reduce (through lower net returns) the stock of domestic capital and decrease the rate of economic growth. For example, in their analysis of tax competition in a two-country world, Lejour and Verbon (1997) observe that:

"...a higher domestic source-based capital-income tax will generate a lower growth rate of wealth" (p. 485) and (through lower net returns) an outflow of capital. Thus, the effect on the international allocation of capital and on economic growth coincide. The use of the overlapping-generations model solves this problem. In this model, first-period consumption differs from second-period consumption; thus, the net-of-tax interest rate does not have to equal the rate of time preference. In this setting, changes in the domestic tax rates affect the interest rate and the individual saving behavior in each country, thereby influencing the international allocation of capital and economic growth in different ways.

This model is used to examine the international effects of domestic source- and residence-based capital taxes. The analysis shows that taxes affect the international allocation of capital, but this static effect is not simply repeated generation after generation. Changes in capital income taxes also affect the rate of growth of capital, and the static and growth effects do not necessarily go in the same direction. A country can increase its share of current world capital by reducing its source-based taxes but, depending on the elasticity of saving to net-of-tax returns, this may reduce its saving level, thus lowering the rate of economic growth; this is a case that appears to have some empirical support (e.g., Berheim, 2002). The analysis also brings out a second important point, namely that the output and the welfare effects of a given tax policy do not necessarily coincide. This is hardly surprising but deserves mentioning because of its specific rationale in the open-economy setting. In an open economy, a distinction exists between the effect of taxes on domestic product and the effect on residents' claims on that product, that is the national income. Politicians are often concerned with the effect of tax reforms on the rate of growth of domestic product, but welfare is concerned with the national income, and the two effects may be different. A country can increase domestic productivity and the growth rate of its product by lowering its taxes, but this may lower the level of domestic saving, thus reducing the claims of its citizens on future product and, therefore, their welfare.

The rest of the paper is organized as follows. The model is formally set up in Section II. Sections III and IV examine the international effects of domestic source- and residence-based capital taxes. Section V summarizes the results and concludes.

II. THE MODEL

Consider a stylized economy consisting of two countries i $(i = 1, 2)$, each inhabited by a single individual or an aggregate of identical individuals, as well as firms and a government. To provide a simple model of individual saving behavior, we use an overlapping generations model in which individuals born at time t live for two periods. The global economy, therefore, consists of two Samuelson-Diamond type economies.

The time structure of the model is as follows. In each country i, individuals work only in the first period of life t, supplying inelastically their labor L_t^i and earning a real wage rate w_t^i and a total wage income $w_t^i L_t^i$. They consume part of this income immediately and save the rest to finance their second-period retirement consumption. The saving of the young at time t can be allocated either domestically or abroad and it generates the capital stock in the following period. For simplicity, individuals are assumed to be immobile, but capital is perfectly mobile across countries. Once the second period arrives, competitive firms operating in each country i combine internationally mobile capital K^i_{t+1} with local labor of the young L^i_{t+1} to produce a single homogeneous output. Each country's output is then either sold as final consumption or purchased by the national government and used to provide an amount G^i_{t+1} per head of public good.[1]

Governments finance their public expenditure through two different types of capital income taxes. Each national government i levies a proportional source-based tax σ^i on income from capital invested in the country. In many countries, these taxes apply to a large number of tax bases including, corporate profits, interests and capital gains. Governments also levy a linear tax ρ^i on residents' income independently of where income originates; that is, they levy a residence-based tax on national savings. Each of these taxes may vary over time, thus each generation t faces domestic tax vectors $\tau^i_{t+1} = \left(\rho^i_{t+1}, \sigma^i_{t+1}\right)$.[2]

As a result of these assumptions, the repatriated return to capital invested in country i, r^i_t, is

$$r^i_t = \left(1 - \sigma^i_t\right) \overline{r}^i_t$$

where $\overline{r}^i_t$ denotes the marginal return that firms pay to capital. The after tax return accruing to national savings invested at home and abroad is, respectively,

$$\begin{aligned} \beta^{ii}_t &= \left(1 - \rho^i_t\right) r^i_t = \left(1 - \rho^i_t\right) \left(1 - \sigma^i_t\right) \overline{r}^i_t \\ \beta^{ij}_t &= \left(1 - \rho^i_t\right) r^j_t = \left(1 - \rho^i_t\right) \left(1 - \sigma^j_t\right) \overline{r}^j_t \end{aligned}$$

where $i, j = 1, 2$ and $i \neq j$. This is the return net-of-saving taxation to country i's residents from capital invested in, respectively, country i and j.

A. Individuals

In each country *i*, the representative member of the generation born at time *t* plans his consumption so as to maximize the utility function[3]

$$u\left(c^i_{1t}, c^i_{2t+1}, L^i_t\right) + m\left(G^i_{t+1}\right)$$

where c^i_{1t} and L^i_t denote the first-period consumption and constant labor supply, respectively,

---

[1] The public good can be seen as a publicly provided private good, so that scale effects are ignored.

[2] The generation born at time t is subject to capital income taxes on returns maturing when old, that is at time $t+1$. Other forms of taxation are, of course, preferable to these taxes which distort investment and saving decisions. In this setting, a tax on labor income, for example, is non-distortionary as labor is inelastically supplied. However, this is equivalent to levying a lump-sum tax, and the purpose of the analysis is to explore decentralized government behavior in the absence of lump-sum taxation. In addition, it is worth noting that in a setting with large countries, national governments may want to use distortionary taxes even if first-best tools are available.

[3] For simplicity, we assume that there is no population growth and normalize total population to be equal to one. This allows us to concentrate on the single representative member of each generation.

with $L_t^i = L^i$; c_{2t+1}^i and G_{t+1}^i denote the second-period consumption and public good provision, and it is assumed that the functions $u(\cdot)$ and $m(\cdot)$ are strictly increasing, strictly quasi-concave and twice continuously differentiable, with $\lim_{c_1^i \to 0} u'_{c_1}(c_1^i, c_2^i) = \lim_{c_2^i \to 0} u'_{c_2}(c_1^i, c_2^i) = +\infty$, and $\lim_{G^i \to 0} m'(G^i) = +\infty$, with public goods entering in a separable manner. The assumptions on public goods are clearly strong. The additive separability of the utility function is unfortunately restrictive, as is the assumption that utility derived from public goods is independent of the circumstances of the recipients.[4]

The representative individual maximizes his utility subject to the lifetime constraints

$$\begin{aligned} w_t^i L^i &= c_{1t}^i + S_t^i \\ S_t^i &= S_t^{ii} + S_t^{ij} \\ c_{2t+1}^i &= \left[1 + \left(1 - \rho_{t+1}^i\right) r_{t+1}^i\right] S_t^{ii} + \left[1 + \left(1 - \rho_{t+1}^i\right) r_{t+1}^j\right] S_t^{ij} \end{aligned}$$

where $i \neq j$. The first constraint states that the first-period wage income, $w_t^i L^i$, can be consumed or saved. In turn, saving S_t^i is invested either home, S_t^{ii}, or abroad, S_t^{ij}. The last constraint requires that, in the second period, the individual consumes all his wealth, including principal and net returns, given tax rates and the after-tax domestic returns r_{t+1}^i and r_{t+1}^j. The individual is supposed to have perfect foresight regarding r_{t+1}^i and r_{t+1}^j, and the future tax rates on capital income both at home and abroad.

Capital is internationally mobile and, in equilibrium, it is allocated across countries so as to equate national after-residence tax returns β_{t+1}^{ii} and β_{t+1}^{ij} (with $i, j = 1, 2$ and $i \neq j$) which implies that $r_{t+1}^1 = r_{t+1}^2$; thus, in equilibrium

$$R_{t+1} = \left(1 - \sigma_{t+1}^1\right) \overline{r}_{t+1}^1 = \left(1 - \sigma_{t+1}^2\right) \overline{r}_{t+1}^2 \tag{1}$$

where R_{t+1} is the economy-wide return to capital before residence tax and depends on both countries' source taxes. As far as their asset allocation is concerned, private investors respond to differences in national source-based taxes σ_{t+1}^i, but not to changes in the residence tax rates ρ_{t+1}^i. In fact, the burden of residence taxation is independent of where savings are invested, and has no effect on the international location of capital.

In equilibrium, the individual is, therefore, indifferent to investing at home (S_t^{ii}) or abroad $\left(S_t^{ij}\right)$, caring only about the level of total saving. We can then consolidate previous constraints into a single present-value budget constraint

$$c_{2t+1}^i = \left[1 + \left(1 - \rho_{t+1}^i\right) R_{t+1}\right] \left(w_t^i L^i - c_{1t}^i\right) \tag{2}$$

The solution to the consumer's problem of maximizing utility subject to (2) is straightforward. Applying the standard method of constrained optimization, the first order condition for a maximum is

$$u'_{c_1}(\cdot) = u'_{c_2}(\cdot) \left[1 + \left(1 - \rho_{t+1}^i\right) R_{t+1}\right] \tag{3}$$

where the conditions on the utility function u ensure that $c_{1t}^i > 0$ and $c_{2t+1}^i > 0$.

[4]For alternative assumptions about the role of public goods, see for example Azariadis (1993).

This also gives us the saving behavior of the single generation in each country i,

$$S_t^i = \xi^i \left(w_t^i L^i, \left(1 - \rho_{t+1}^i\right) R_{t+1} \right) = \xi^i \left(w_t^i L^i, \beta_{t+1}^i \right) \tag{4}$$

where, differentiating with respect to the variables w_t^i and β_{t+1}^i, we obtain $0 < \xi_{w_t^i}^{i\prime} < 1$, while the sign of $\xi_{\beta_{t+1}^i}^{i\prime}$ is undetermined. In this model, saving is an increasing function of wage-income, but the effect of the net rate of return β_{t+1}^i is ambiguous. An increase in the interest rate (or a decrease in the tax rates) leads individuals to shift consumption from the first to the second period (substitution effect), but it also makes it possible to increase consumption in both periods (income effect). The overall impact of these effects depends on the elasticity of substitution between consumption in the first and second period of life. If this elasticity is greater (smaller) than one (where one is assumed to be the expenditure elasticity), then the substitution (income) effect dominates, and an increase in the rate of return β_{t+1}^i, or a lower tax rate, leads to an increase (decrease) in saving.

It may be noticed that the behavior of generation t depends on both domestic and foreign taxes. It directly depends on the domestic residence tax rate ρ_{t+1}^i and through the worldwide return to capital R, it also depends on the source tax rate at home and abroad $\left(\sigma_{t+1}^i, \sigma_{t+1}^j\right)$.

At times, it may be convenient to work with homothetic utility functions. In this case, the optimal conditions take, in fact, a particularly simple form with saving being linear in the wage income:

$$S_t^i = s^i \left(\left(1 - \rho_{t+1}^i\right) R_{t+1} \right) w_t^i L^i \tag{5}$$

If we further restrict the attention to the special case with Cobb-Douglas utility functions, the factor $s^i(\cdot)$ becomes a constant (see Appendix I). In what follows, these simple examples will be useful in discussing a number of tax-related issues.

B. Firms

In each country i, firms act competitively, hiring local labor and renting capital to produce a single homogeneous output according to the aggregate net production technology $F_i\left(A^i, K_t^i, L^i\right)$. This is a twice continuously differentiable function with decreasing returns in capital and labor, and a local productivity factor A^i.[5]

To model continual endogenous growth, we assume that firms in each country accumulate new capital and inadvertently contribute to the productivity of capital locally invested by others. In this sense, production spillovers exist that are national in scope, and the productivity factor may be defined as $\overline{A}^i\left(K_t^i\right)$. This represents uncompensated spillovers of knowledge or ideas from one producer to another within the same country as for example in Arrow (1962).

In an integrated world economy countries have access, however, to a larger set of knowledge and technologies than they have in a non-integrated environment. In particular, the stock of capital available abroad affects productivity at home, and international mobility of this capital

[5]It is also assumed, for convenience, that the function $F_i(\cdot)$ satisfies the Inada conditions with respect to the stock of domestic capital K_t^i.

implies transfers of technology and ideas, so that technology spills over from one country to others. To capture these cross-border technological externalities, the productivity factor may be redefined as $A^i\left(K_t^i, K_t^j\right)$, where $i \neq j$ (Bertola, 1993). With this formulation, capital abroad affects productivity at home and cross-country capital flows imply international transfers of technology and knowledge. This mechanism of growth is a very simple extension of the learning by doing model originally proposed by Arrow (1962), and later studied by Romer (1986). In addition, however, it takes into account the fact that domestic production and investment cannot be independent when countries are economically integrated.[6]

The existence of international growth externalities has recently received widespread attention. Coe and Helpman (1995), for example, analyzed the effects of R&D spending in OECD countries and concluded that each country's total factor productivity significantly depends on foreign R&D capital. Using a special version of the IMF's MULTIMOD, these authors (and Bayoumi, 1999) calculated that[7]

"When all industrial countries raise R&D spending by an amount equivalent to $\frac{1}{2}$ of 1% of GDP, the long-run US output gain is 50% higher than in the case when only US R&D spending rises." (Bayoumi *et al*, 1999, p. 425)

Turning to the details of the model, in each country *i* the production function $F_i\left(A^i, K_t^i, L^i\right)$ is assumed to be linearly homogeneous in the domestic stock of capital K_t^i and in the productivity factor A^i. In turn, the productivity factor is linearly homogeneous in K_t^i and K_t^j, and at the limit $A^i \rightarrow 0$ as $K_t^i \rightarrow 0$ or $K_t^j \rightarrow 0$, so that positive productivity requires a positive level of capital in both countries. The assumption that the productivity factor A^i is linearly homogeneous in capital stocks is the natural counterpart of the typical AK-model of growth that has been so widely used in single country models. In these models, the linear-homogeneity assumption captures the productivity spillover in national context. In a two-country context, however, it would not be reasonable to assume that the foreign capital simply adds to the domestic effect, thereby generating increasing returns to capital. Rather, the assumption here is that domestic and foreign capital combine to have the same impact on productivity as assumed in a single country model.

Under these assumptions, we can write the output in each country *i* as

$$F_i\left(A^i\left(K_t^i, K_t^j\right), K_t^i, L^i\right) = f_i\left(a_i\left(\frac{K_t^j}{K_t^i}\right)\right) K_t^i = H_i\left(\alpha_t\right) K_t^i$$

where the constant supply of labor L^i has been omitted, and $\alpha_t = \frac{K_t^j}{K_t^i}$, with $i \neq j$. We then have a sort of open-economy version of an AK-model where endogenous growth is sustained by a positive external effect of both domestic and foreign capital stocks on total factor productivity. It is worth noting that in this model, the return to capital is constant in the aggregate, and this is a sufficient condition for having economic growth; however, decreasing returns still prevail

[6]For discussion of international spillovers of knowledge, see for example Bertola (1993), and Grossman and Helpman (1994).

[7]For empirical evidence of international spillovers of R&D spending, and references to the literature, see also Bernstein and Mohnen (1998), and Leahy and Neary (1999).

when domestic capital is considered separately. In addition, domestic production depends on how capital is located between the two countries.

In this context, profit-maximizing competitive firms pay factors their marginal productivity

$$\begin{array}{c} \overline{r}_t^i = F'_{ik_t^i} \mid_{A^i} \left(A^i, K_t^i\right) = \overline{r}^i \left(\alpha_t\right) \\ \frac{w_t^i}{K_t^i} = H_i \left(\alpha_t\right) - \overline{r}^i \left(\alpha_t\right) = \omega^i \left(\alpha_t\right) \end{array} \tag{6}$$

where $F'_{ik_t^i} \mid_{A^i}$ is the marginal productivity of capital for the single firm which takes the productivity factor A^i as exogenously given, and the dependence of the $\overline{r}^i$ and ω^i functions derives from the property of linear homogeneity of the production function.

It may be noticed that at each time the interests of capital owners (the old people) do not necessarily coincide with those of wage earners (the young). Increases in the relative allocation of domestic capital (the ratio α_t) rise, in fact, the private marginal product of capital and have ambiguous effects on that of labor, possibly decreasing it, as

$$\begin{array}{c} \overline{r}_{\alpha_t}^{i\prime} \left(\alpha_t\right) > 0 \\ \omega_{\alpha_t}^{i\prime} \left(\alpha_t\right) = H'_{i\alpha_t} \left(\alpha_t\right) - \overline{r}_{\alpha_t}^{i\prime} \left(\alpha_t\right) \lesseqgtr 0 \end{array}$$

where $H'_{i\alpha_t} \left(\alpha_t\right)$ is positive, so that the sign of $\omega_{\alpha_t}^{i\prime} \left(\alpha_t\right)$ is ambiguous. This creates a potential intergenerational conflict that is of great importance in examining the intertemporal effects of capital taxes.

At times, it is convenient to work with the more restrictive class of Cobb-Douglas production functions

$$Y_t^i = \left[\left(A^i\right)^{\frac{1}{1-\epsilon}}\right]^{1-\epsilon} \left(K_t^i\right)^{\epsilon} \left(L^i\right)^{\vartheta} \qquad \text{with } \epsilon > 0, \vartheta < 1$$

and with a multiplicative form for the productivity spillovers

$$A^i = \eta_i \left(K_t^i\right)^{\mu} \left(K_t^j\right)^{\mu^*} \qquad i, j = 1, 2 \text{ and } i \neq j$$

where $\mu + \mu^* = 1 - \epsilon$ and $\mu, \mu^*, \eta_i > 0$ in both countries so to satisfy previous assumptions.

In this case, the national product Y_t^i, the private return to capital $\overline{r}_t^i$, and the wage rate w_t^i take a very simple form, all being functions of the international allocation of capital $\alpha_t = \frac{K_t^j}{K_t^i}$,

$$\begin{array}{c} Y_t^i = \eta_i \left(L^i\right)^{\vartheta} \alpha_t^{\mu^*} K_t^i \\ \overline{r}_t^i = F'_{ik_t^i} \mid_{A^i} = \epsilon \eta_i \left(L^i\right)^{\vartheta} \alpha_t^{\mu^*} \\ w_t^i = \left(1 - \epsilon\right) \eta_i \left(L^i\right)^{\vartheta} \alpha_t^{\mu^*} K_t^i \end{array}$$

In this simplified case, the private rate of return is not a function of domestic capital K_t^i, other than through α_t, whereas domestic product and wage rise proportionally with K_t^i.

C. Public Sector

As seen earlier, in each country i the government provides an amount of local public goods G_{t+1}^{i} to each generation t and finances these expenditures by levying distortionary taxes on the residents' income from saving and on income from domestically invested capital $\left(\rho_{t+1}^{i}, \sigma_{t+1}^{i}\right)$. If one unit of output can be transformed to one unit of public good, each government i's revenue constraint may be then written as

$$G_{t+1}^{i} = \sigma_{t+1}^{i} \overline{r}^{i} \left(\alpha_{t+1}\right) K_{t+1}^{i} + \rho_{t+1}^{i} r_{t+1}^{i} S_{t}^{ii} + \rho_{t+1}^{i} r_{t+1}^{j} S_{t}^{ij} \tag{7}$$

where variables are per capita as there is no population growth and population has been normalized to one. The first term on the right-hand side of this expression denotes revenue from the source-based tax σ_{t+1}^{i}, and the other two terms indicate revenue from taxes on the return to national savings at time t; these savings are invested, respectively, at home and abroad, and yield a return at time $t+1$.

As the reader may have already noticed, government debt has been ignored. In this model with overlapping generations, debt policy would, in fact, be equivalent to levying differential lump-sum taxes, and our purpose is to explore decentralized government behavior in the absence of these taxes.[8]

D. Market Equilibria and Accumulation

At this point, we can complete the building blocks of this two-country model of growth, and determine the equilibria in the national factor markets and in the world capital market, as well as derive the law of capital accumulation for this economy.

National factor markets equilibria

There are two factor markets in each country, one for labor and one for capital services. Labor is inelastically supplied by individuals and the supply of capital at each time t is determined by the saving decisions made in the previous period. Equilibrium in national factor markets is obtained when the wage and the rental rate on capital are such that competitive firms wish to use the available amount of labor and capital services. Therefore, the factor market equilibrium conditions are given by equations (6). It may be worth noting that the wage w_{t}^{i} and the rental cost of capital $\overline{r}_{t}^{i}$ need not to be the same in the two countries.

World capital market equilibria and accumulation

Equilibrium in the international market of capital requires that capital is allocated across countries so that it equals national net returns (see condition (1)). Using previous equilibrium conditions (6) for domestic returns $\overline{r}_{t+1}^{i}$, we have:

$$R_{t+1} = \left(1 - \sigma_{t+1}^{i}\right) \overline{r}^{i} \left(\alpha_{t+1}\right) = \left(1 - \sigma_{t+1}^{j}\right) \overline{r}^{j} \left(\alpha_{t+1}\right) \tag{8}$$

---

[8] For discussion of the equivalence between government debt policy and differential lump-sum taxation in overlapping generations models, see for example Diamond (1973, p. 222) and Atkinson and Sandmo (1980, p. 533).

with $i, j = 1, 2$ and $i \neq j$.

Capital market equilibria also require that the total demand for capital in each period be equal to the supply or that world investment be equal to world saving:

$$\begin{aligned} \overline{K}_{t+1} &= K^i_{t+1} + K^j_{t+1} = S^i_t + S^j_t = \\ &= \xi^i\left(\omega^i\left(\alpha_t\right) K^i_t, \left(1-\rho^i_{t+1}\right) R_{t+1}\right) + \xi^j\left(\omega^j\left(\alpha_t\right) K^j_t, \left(1-\rho^j_{t+1}\right) R_{t+1}\right) \end{aligned} \tag{9}$$

where $\overline{K}_{t+1}$ is the total stock of capital in the economy, and we have used the equilibrium conditions (6) for w^i_t, with $i, j = 1, 2$ and $i \neq j$. This condition implies that the total stock of capital at time $t+1$ is equal to the total world saving of the young inherited from the past.

It may be noticed that in each country, the stock of capital can be greater or smaller than domestic saving. In open economies, domestic savings can be, in fact, invested both at home and abroad, so that the location of physical capital and the value of claims on domestic and foreign capital by home residents, namely national income, no longer coincide. As in the national income accounts, we then need to distinguish between *domestic product* produced with the available capital and *national income,* that is residents' claims on the world product.

We can solve previous condition (8) for the equilibrium capital ratio $\alpha_{t+1} = \frac{K^j_{t+1}}{K^i_{t+1}}$ as a function of the source-based taxes $\left(\sigma^i_{t+1}, \sigma^j_{t+1}\right)$,

$$\alpha_{t+1} = \frac{K^j_{t+1}}{K^i_{t+1}} = \alpha\left(\sigma^i_{t+1}, \sigma^j_{t+1}\right) \qquad i, j = 1, 2 \text{ and } i \neq j$$

This is an increasing function in σ^i_{t+1} and declining in σ^j_{t+1}. Substituting this expression in the equilibrium condition (8), we obtain the equilibrium world-wide return to capital R_{t+1},

$$R_{t+1} = R\left(\sigma^i_{t+1}, \sigma^j_{t+1}\right) \qquad i, j = 1, 2 \text{ and } i \neq j$$

The world-wide return R_{t+1} is a declining function in the source taxes and it is independent of the stock of capital. This special feature derives from our cross-country mechanism of growth and makes the model particularly tractable.[9]

At this point, we can derive the law of capital accumulation in each country. In particular, we can substitute previous expressions for α_{t+1} and R_{t+1} in condition (9) and using the fact that $K^j_{t+1} = \alpha_{t+1} K^i_{t+1}$ and the dependence on tax variables, we obtain

$$K^i_{t+1} = \frac{\overline{K}_{t+1}}{1+\alpha_{t+1}} = \frac{S^i_t + S^j_t}{1+\alpha_{t+1}} = h^i\left(k_t, \tau^i_{t+1}, \tau^j_{t+1}\right) \tag{10}$$

$$K^j_{t+1} = \alpha_{t+1} K^i_{t+1} = \alpha_{t+1} \frac{\left(S^i_t + S^j_t\right)}{1+\alpha_{t+1}} = h^j\left(k_t, \tau^i_{t+1}, \tau^j_{t+1}\right)$$

[9]For an explicit calculation of the ratio α_{t+1} and the rate R_{t+1} in the case of Cobb-Douglas production functions, see Appendix I.

where $\tau_{t+1}^{i}=\left(\rho_{t+1}^{i},\sigma_{t+1}^{i}\right)$ is the vector of tax rates in each country i, and $k_t=\left(K_t^i,K_t^j\right)$ is the vector or inherited stocks of capital in both countries with $i,j=1,2$ and $i\neq j$. These equations give us the law of capital accumulation and the dependency on tax policy. In each country, the stock of capital at time $t+1$ is a function of the inherited stocks of capital in both countries, the vector k_t, as they both influence domestic factor prices, and of governments' tax decisions $\tau_{t+1}^{i},\tau_{t+1}^{j}$.

It may be noticed that the stock of capital in each country depends on both countries' domestic tax rates. As a result, changes in one country's tax rates influence capital accumulation both at home and abroad. Clearly, the model does not, without further restrictions on the utility and production functions, guarantee either existence or uniqueness of an equilibrium accumulation path for this economy. In what follows, we assume that a unique equilibrium with positive capital exists, and Appendix I presents a Cobb-Douglas version of this model where an equilibrium does exist.[10]

III. Tax Interdependencies in Open Economies

The analysis of previous sections suggests that there are a number of different channels through which domestic taxation of capital exerts international effects. First, domestic taxes affect the international allocation of the existing stock of world capital. This effect has long been at the center of public debate and of the literature on international taxation (for a recent survey, see Wilson 1991). This is not, however, the only effect.

Second, domestic taxes affect international growth and how capital accumulates over time. A country can influence, for example, the level of saving both at home and abroad by changing its capital income taxes, hence affecting the international rate of capital accumulation and economic growth. As the analysis will show, this growth effect may well differ from the static effect on the international allocation of capital, so that the static argument cannot be simply repeated generation after generation.

Third, the analysis suggests that an important distinction exists between the effect of taxes on *domestic product* and the effect on *national income*, namely the claims of residents on the world product. This distinction is important. Politicians seem often concerned with domestic product, and welcome low taxes as a means of achieving higher rates of economic growth. Economists, on the other hand, are more interested in the welfare effects of taxation, and welfare is concerned with national income. Although both growth and welfare may be legitimate performance criteria, the distinction is important as the two criteria may lead to very different conclusions as to the effect of taxes.

Finally, domestic taxation of capital has important international distributional effects. Changes in national taxes in one country influence the welfare of individuals both at home and abroad through changes in the international allocation of capital α_t, thus in factor prices. For example, a higher domestic source-based tax in country i leads to a relatively smaller stock of home capital (the

[10]For discussion of the existence and uniqueness of equilibria in overlapping generations models, and reference to the literature, see Blanchard and Fisher (1989), and Azariadis (1993). For applications to models with open economies and to models with endogenous growth, see also Buiter (1981), and Buiter and Kletzer (1992).

ratio α_t decreases), and suppose that this also induces an increase in the level of national wages since, for instance, $\omega_{\alpha_t}^{i\prime}(\alpha_t) < 0$. As a result, the welfare of the young people currently alive at home rises. At the same time, the tax also affects the welfare in the foreign country. In fact, it decreases the welfare of young abroad since the tax-generated capital inflow lowers their wages. The welfare effects of a tax change may be complex.

It is to some of these issues that we now turn.

IV. The Effect of Taxation in a Two-Country World

In this section, we consider the international effects of domestic tax policies. In particular, we consider two issues: the impact of domestic taxes on the international allocation of capital and the impact on the rate of economic growth both at home and abroad. These issues have been at the centre of the public debate on capital income taxation, but they are often confused. The distinction is, however, important. If it is argued that a reduction in capital income taxes fosters accumulation, then we need to know whether it increases the level of capital or whether it raises the rate of capital accumulation. The numerical measure of the supposed advantage may be very different and so is the assessment of the proposed tax reduction. In order to provide a rigorous discussion of these questions, we introduce two concepts of equilibria: the static or "momentary" equilibrium, and the dynamic or "intertemporal" equilibrium.

A. Momentary Equilibria and International Allocation of Capital

The effect of domestic taxes on the international allocation of capital has been the subject of much attention in the literature on capital taxation, and it is from this issue that we start our discussion. To examine this effect, we need to introduce the concept of single-period or momentary equilibrium. This is defined as an international allocation of capital that, given tax rates, implies equilibrium in both countries' national markets. It may then be characterized by a set of prices $\{w_t^i, r_t^i\}$ and consumption-savings allocations such that, in each country, firms maximize profits, agents maximize utility, and governments satisfy their budget constraints. The exact equilibrium clearly depends on the existing national fiscal policies $\{\rho_t^i, \sigma_t^i, G_t^i\}$, and on the aggregate stock of capital, $\overline{K}_t$, inherited at the beginning of the period. At each time t, the momentary equilibrium can, therefore, be fully described as a function of the current national policies and the inherited stock of capital.

The momentary equilibrium can be used to determine the international allocation of capital at each instant and the dependence of tax rates. In particular, in equilibrium the aggregate stock of capital $\overline{K}_t$ must be located between the two countries, so that $\overline{K}_t = K_t^i + K_t^j$ and $\frac{K_t^j}{K_t^i} = \alpha\left(\sigma_t^i, \sigma_t^j\right)$ (as derived from the arbitrage condition (8)) with $i, j = 1, 2$ and $i \neq j$. These conditions provide a system of equations that can be solved for the equilibrium amount of capital in each country i, K_t^i, as a function of the vector of source-based taxes $\left(\sigma_t^i, \sigma_t^j\right)$, given the stock of capital, $\overline{K}_t$. At each time t, we then have that

$$K_t^i = d^i\left(\sigma_t^i, \sigma_t^j, \overline{K}_t\right) \qquad\qquad i, j = 1, 2 \text{ and } i \neq j$$

At each instant, the equilibrium allocations of capital $\left(K_t^i, K_t^j\right)$ depends on the source-based tax rates σ_t^i and σ_t^j, but not on residence taxation. Residence taxes do not, in fact, discriminate residents' investment across different countries. Changes in residence taxes do, of course, affect the individual saving behavior and the future inherited stock of capital, but at each instant they leave the momentary equilibrium, and the international allocation of the existing stock of capital, unchanged.

What does this tell us about the effect of domestic taxes on the allocation of capital? Differentiating previous condition (8) using equations (6) for $\overline{r}^i\left(\alpha_{t+1}\right)$, with $i, j = 1, 2$ and $i \neq j$, and evaluating the expression for the simplest case of symmetric countries, we obtain that at each time t,

$$\frac{dK_t^j}{d\sigma_t^i} = -\frac{dK_t^i}{d\sigma_t^i} = -\frac{F'_{ik_t^i}\mid_{A^i}}{2\left(1-\sigma_t^i\right)\left(F'_{ik_t^i}\mid_{A^i}\right)'_k} > 0 \qquad i, j = 1, 2 \quad i \neq j$$

as from the properties of production functions, $\left(F'_{ik_t^i}\mid_{A^i}\right)'_k < 0.$

In equilibrium, the amount of capital in each country is a declining function of the domestic source tax, but an increasing function of the other country's tax rate. In this setting, each country should then be concerned that increases in domestic source taxes lead to an outflow of capital to foreign countries. It is this externality that has received much attention in the literature on international capital taxation.

To get a better understanding of the international effect of domestic taxes, it may be useful to work out a specific example with Cobb-Douglas production functions. In this case, the equilibrium allocation of capital in each country i takes a very simple form.[11]

In this simple example, the international allocation of capital and the effect of taxes can be illustrated in figure 1. In this figure, both countries' net rates of return are plotted together as a function of the variable $\chi = \frac{K^1}{\overline{K}}$, where $0 \leq \chi \leq 1$. The capital market is in equilibrium when $r_t^1 = r_t^2$, that is at the intersection point I where condition (8) holds.

[11]For a version of this model with Cobb-Douglas functions, see Appendix I. In this case, $r_t^1 = \epsilon\eta_1\left(L^1\right)^{\vartheta}\left(\frac{1-\chi}{\chi}\right)^{\mu^*}\left(1-\sigma_t^1\right)$ and $r_t^2 = \epsilon\eta_2\left(L^2\right)^{\vartheta}\left(\frac{\chi}{1-\chi}\right)^{\mu^*}\left(1-\sigma_t^2\right)$ where $\chi = \frac{K^1}{\overline{K}}$.

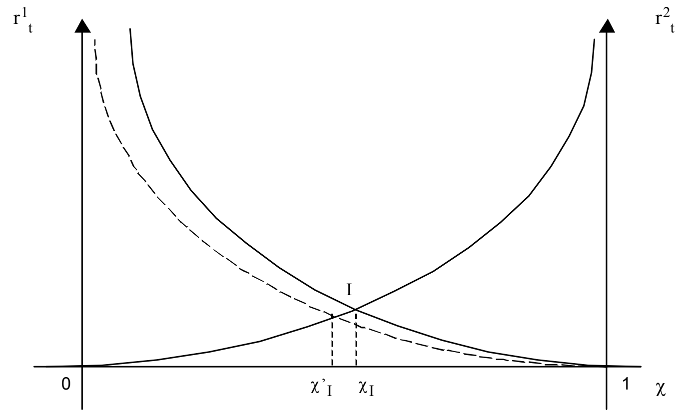

Figure 1. Momentary Equilibrium

As shown in the figure, any increase in the domestic source tax rate (e.g., in country 1) shifts the net-return curve of the country downwards (the dashed line). This leads to an international reallocation of capital with a lower domestic capital stock and a higher level of capital in the other country (i.e. a smaller χ). In equilibrium, the international interest rate also falls as a result of the higher source-based tax rate. This cross-country capital flow effect can be interpreted as a one-period or static fiscal externality of domestic policy and has been often discussed in the literature on international capital taxation.

This example brings out an important point: that the capital relocation effect is a pure static or single-period effect and does not depend on capital accumulation and economic growth. To illustrate this point, consider the case with Cobb-Douglas production functions with no externalities and no economic growth (so that $\mu = \mu^* = 0$ and $0 < \epsilon < 1$). As in the previous case, an international equilibrium exists. In this equilibrium, changes in domestic tax rates lead, again, to a reallocation of capital in favor of the tax-reducing country.[12]

It is not, of course, suggested that economic growth is unimportant; however, an important distinction exists between the effect of domestic taxes on the international allocation of the current capital, which is static, and the impact on economic growth, which is dynamic. It is the static relocation effect which has received much attention in the debate on capital taxation, but this is not the only effect we should consider. A tax change also affects the growth process and the future stock of capital at any instant. Indeed, the static analysis cannot be simply repeated generation after generation, and it is to this dynamic effect that we now turn.

[12] In this case, the net return to capital in each country may be written as $r_t^1 = (1-\sigma_t^1)\,\epsilon\eta_1\,(L^1)\,\overline{K}_t^{\epsilon-1}\left(\frac{1}{\chi}\right)^{1-\epsilon}$ and $r_t^2 = (1-\sigma_t^2)\,\epsilon\eta_2\,(L^2)\,\overline{K}_t^{\epsilon-1}\left(\frac{1}{1-\chi}\right)^{1-\epsilon}$ and we can draw a diagram analogous to that of Figure 1 where the national net return curves again decrease, crossing the vertical lines at a positive value above zero.

B. Intertemporal Equilibria, Economic Growth, and Welfare

Much of the political rhetoric about capital tax reforms has centered round the effects on economic growth; but, how exactly do domestic taxes influence growth in an integrated economy? To consider this, we need to introduce the concept of intertemporal equilibrium. This can be defined as that sequence of momentary equilibria in which national consumption profiles steadily grow from generation to generation, given the sequence of prevailing fiscal policies $\{\rho_t^i, \sigma_t^i, G_t^i\}_{t=0}^{\infty}$ in each country.

To simplify the analysis, let us focus the attention on the growth rate of domestic product, and let us assume for convenience that national policies are constant. In this case, we can use the property of linear homogeneity of production technologies and write each country's product as a function of the capital ratio α and of a single country's stock of capital; we have, for example, that

$$\begin{aligned} Y_t^1 &= F_1\left(A^1\left(K_t^1, K_t^2\right), K_t^1\right) = H_1\left(\alpha\right) K_t^1 \\ Y_t^2 &= F_2\left(A^2\left(K_t^1, K_t^2\right), K_t^2\right) = H_2\left(\alpha\right) K_t^1 \end{aligned}$$

where, the inelastic supply of labor has been omitted, and the capital ratio $\alpha\left(\sigma_t^i, \sigma_t^j\right)$ is constant because of constant tax policies. The domestic product in the two countries thus grows at a common rate. However, it should be noticed that the claims on that product, i.e. the national income, may grow at different rates as these depend on domestic savings. For example, one country may save more than the other, so that it will come to own an increasing share of the entire world product. Thus, domestic product and national income do not necessarily grow at the same rate. From previous expressions, it also follows that domestic tax policies may affect both the world-wide growth rate and the distribution of production across countries by changing the ratio α because growth and distribution depend on how capital is internationally allocated; however, tax policy cannot generate differences in the countries' rates of growth of domestic product.

At this point, we can examine the effect of domestic taxes on the rate of economic growth in this two-country economy. To this purpose, we can focus on a single country since the other is characterized by identical dynamics. In particular, previous accumulation equations (10) give us the law of motion of capital in each country i,

$$K_{t+1}^i = h^i\left(K_t^i, K_t^j, \tau^i, \tau^j\right) \qquad i, j = 1, 2 \qquad i \neq j$$

where $\tau^i = \left(\rho^i, \sigma^i\right)$ and $\tau^j = \left(\rho^j, \sigma^j\right)$, and we have dropped the time index for the tax rates as these are constant. This equation describes a relationship between the domestic stock of capital K_{t+1}^i and K_t^i at different times, given the vectors of tax rates τ^i and τ^j and the fact that the inherited stock of capital in the other country can be written in term of the domestic stock of capital as $K_t^j = \alpha K_t^i$. Therefore, with well behaved utility functions, the dynamics can, eventually, be expressed as

$$K_{t+1}^i = \left(1 + g_i\right) K_t^i \qquad i = 1, 2 \tag{11}$$

where $g_i = g\left(\tau^i, \tau^j\right)$ is constant (for an example see appendix I).

Equation (11) gives us the rate of economic growth in each country, and in the entire economy, as a function of domestic and foreign tax rates. Thus, the growth rate in each country is not function of domestic fiscal decisions only: the tax rates of the other country also affect the domestic growth rate, much in the same way as an externality.[13] In fact, domestic taxes create an intertemporal or "growth" externality. The main interest of this model rests precisely in these intertemporal transmission effects. Unfortunately, previous equations do not allow us to directly examine the growth effects of domestic taxes since the functional forms of the problem are unknown.[14]

To get a better understanding of the effects of domestic taxes on international growth, it is useful to work out a specific example. We may consider for simplicity countries that are symmetric but for their tax policy, use the Cobb-Douglas technologies described above, and introduce homothetic utility functions.[15] For this class of utility functions, the individual optimality conditions take, in fact, a very simple form with the saving in each country depending on the stock of domestic capital (equation (5)),

$$\begin{aligned} S_t^i &= s\left(\beta_{t+1}^i\right)(1-\epsilon)\,\eta_i\left(L^i\right)^{1+\vartheta}\alpha^{\mu^*}K_t^i \\ S_t^j &= s\left(\beta_{t+1}^j\right)(1-\epsilon)\,\eta_j\left(L^j\right)^{1+\vartheta}\left(\frac{1}{\alpha}\right)^{\mu^*}\alpha K_t^i \end{aligned}$$

where $\beta_{t+1}^i = (1-\rho^i)\,R_{t+1}$. Substituting these expressions in (10), $K_{t+1}^i = \frac{S_t^i + S_t^j}{1+\alpha_{t+1}}$, we obtain a very simple expression for the rate of economic growth

$$\frac{K_{t+1}^i}{K_t^i} = 1 + g_i = (1-\epsilon)\,s\left(\beta_{t+1}^i\right)(L)^{1+\vartheta}\left(\frac{\alpha^{\mu^*}+\alpha^{1-\mu^*}}{1+\alpha}\right) \tag{12}$$

where, for convenience, the terms η_i, η_j have been normalized to be equal to one, and $L^i = L^j = L$.[16]

Armed with this simple example, we can now examine the international effects of national taxation on economic growth, and we start considering the impact of residence taxation. From

---

[13] It may be noticed that in this model with perfect capital mobility there are no transitional dynamics, and the economy is always at its balanced growth path. However, as noted in previous sections, the existence and uniqueness of a balanced accumulation path with positive economic growth are not guaranteed. In what follows, we assume that a unique equilibrium for any given set of tax rates exists, and Appendix I provides an example with Cobb-Douglas utility and production functions where a unique equilibrium exists indeed.

[14] We may notice that, in this model, changes in domestic taxes have strong international effects. Specifically, changes in one country's taxes has as strong an effect on domestic growth as on foreign growth. This undesirable feature of this model derives from the fact that the model has no transitional dynamics and perfect mobility of capital. Introducing these dynamics an imperfect capital mobility would lead to country differentiated effects. However, the purpose of the analysis is to examine the effects of domestic tax policies along the balanced growth path, and the absence of transitional dynamics greatly simplifies this task.

[15] It is worth noting that for a steady state to exist, preferences must be homothetic; see for example Buiter and Kletzer (1992).

[16] For a simplified version of this model with Cobb-Douglas utility and production functions, see appendix I. In this example, conditions on the parameters of the model can be found such that a positive long-run growth rate for the economy indeed exists (see Appendix I).

equation (12), we can observe that residence taxes have no effects on the international allocation of capital α as $\alpha\left(\sigma^{i},\sigma^{j}\right)$, but they do affect the rate of growth through changes in the saving propensity factor $s\left(\beta_{t+1}^{i}\right)$. In particular, an increase in residence taxes has a zero, positive or negative impact on the national (as well as foreign and international) rate of growth, depending on whether the elasticity of substitution at home is equal, smaller or greater than one (where one is the value of the expenditure elasticity for homothetic utility functions). A clear distinction exists between the static effect of residence taxes on the international allocation of capital and the dynamic effect on economic growth.

We conclude that residence taxes do not affect the international allocation of capital, but they may raise or lower capital accumulation; in fact, they are not necessarily harmful to economic growth. Higher residence taxes change the saving behavior of generations and, if the elasticity of substitution is, for example, smaller than one, then they eventually boost economic growth. This result has long been known in the theoretical literature on saving behavior and a large volume of empirical work suggests that elasticities of substitution are indeed generally less than unity. Thus, the empirical possibility exists that increases in residence taxation do lead to faster growth, while leaving the international allocation of capital unchanged.[17]

The effect of changes in the source-based tax rates, σ^{i}, are more complex to examine. As clear from previous equation (12), source taxes affect the growth through two channels. They influence the propensity to save $s\left(\cdot\right)$, as well as the international allocation of capital, $\alpha\left(\cdot\right)$, thus leading to ambiguous effects on the rate of growth.

Some definite conclusions can be, however, reached if we restrict further the attention to the special case of Cobb-Douglas utility functions. In this case, $s\left(\cdot\right)$ becomes a constant, and national growth rates take a very simple form,

$$\frac{K_{t+1}^{i}}{K_{t}^{i}}=1+g_{i}=s\left(1-\epsilon\right)\left(L\right)^{1+\vartheta}\left(\frac{\alpha^{\mu^{*}}+\alpha^{1-\mu^{*}}}{1+\alpha}\right)$$

where $\alpha^{\mu^{*}}=\left(\frac{\left(1-\sigma_{t}^{j}\right)}{\left(1-\sigma_{t}^{i}\right)}\right)^{\frac{1}{2}}$ with $i,j=1,2$ and $i\neq j$ (see appendix I). Under this assumption, the rate of growth g_{i} is thus independent of the residence-based tax rates ρ^{i}, but it depends on source taxation through the ratio $\alpha\left(\sigma^{i},\sigma^{j}\right)$.

In this special case, there is a national tax (or subsidy) rate σ^{i*} which, given the parameters of the model, maximizes the rate of economic growth.[18] Clearly, there is a non-monotonic relation between source-based taxes and the rate of economic growth, and this takes the form of a Laffer curve-type relation. This relation is the result of the special cross-country growth

[17] A large volume of empirical work which seeks to determine the effects of capital taxation on personal savings and economic growth exists which suggests the possibility of low elasticity of substitution. For discussion of this evidence, and references to the literature, see for example Atkinson and Stiglitz (1980), (Hall, 1988), Uhlig and Yanagawa (1996), and Bernheim (2002).

[18] For example, the term in the bracket is maximized at $\alpha=1$. From the definition of α, it then follows that, the growth rate is maximum when $\sigma^{1*}=\sigma^{2*}$. These may be either taxes (positive) or subsidies (negative), depending of the exact parameterization of the model.

mechanism $A^i\left(K_t^i, K_t^j\right)$. With this mechanism, only one international allocation of capital exists that maximizes growth externalities, and this can only be achieved with specific national source tax rates.

This special case brings out the important point that lower source taxes increase the stock of domestic capital but they do not necessarily raise the rate of economic growth. Growth depends, in fact, on how capital is allocated across countries. For example, any change away from the growth maximizing tax rate, even lower taxes or higher subsidies, increases the domestic share of the existing stock of world capital, but reduces the rate of growth both at home and abroad. Clearly, an important distinction exists between the static effect of domestic source taxes on the international allocation of capital and the dynamic effect on the rate of growth, and these effects may well differ.

This simple example also serves to show that the effect of a tax change on domestic product may be different from the effect on national income, namely welfare. This can be seen with a simple example. Suppose that the despite the assumption of symmetric countries, country i levies a lower source tax than country j. In this case, an increase in country i's source tax would raise the rate of growth of domestic product but, under specific parameterization of the model, it will also lower domestic saving, hence reducing the national income.[19] Clearly, the supposed advantage of a tax change varies with the performance criterion we adopt, in this case domestic product and welfare (national income). Considerable circumspection is then necessary in assessing the effect of a tax policy in a dynamic model.

C. Comparing Predictions

The predictions of the model described here may be compared with those others have reached in infinite-life Ramsey models. In their analysis of public finance and economic growth, for example, Barro and Sala-I-Martin consider a Ramsey model with different mechanisms of growth, and conclude:

"Putting the results together, the implication is that the models predict positively correlated movements in r (*the net rate of return*) and γ (*the rate of economic growth*)." (Barro and Sala-I-Martin, 1992, p. 655)

thus, capital taxes reduce net returns and the rate of growth. They examine a closed economy, but the same result applies to the case of open economies with internationally mobile capital. Lejour and Verbon (1997), for example, use a Ramsey accumulation model to investigate the issue of tax competition in a two-country world, and observe

"So, a higher domestic source-based capital-income tax will generate a lower growth rate of wealth, ..." (Lejour and Verbon, 1997, p. 485)

Thus, the effect of domestic taxes on the international allocation of capital and on economic

---

[19]This result holds, for example, under the assumption that $\mu^* = 0.5$ and $s\left(1-\epsilon\right)\left(L\right)^{1+\vartheta} > \frac{1+\alpha}{\alpha^{\mu^*}+\alpha^{1-\mu^*}}$, which is also a sufficient condition for growth to be positive (see appendix I). Other parameterisations can also be found.

growth coincide.

The main reason these conclusions are different from ours is that they draw on infinite-lived Ramsey models of accumulation. In these models, time preferences limit opportunities for cross-country tax and growth dependences.[20] Suppose, for example, that each national economy consisted of Ramsey infinite-lived optimizing individuals who maximize the infinite stream of their utility discounted by their rates of time preference. In this case, the long-run equilibrium stock of capital in each country is given by the so-called modified "golden rule" (see for example in Blanchard and Fisher, 1989, p. 57). This requires that, in the stationary state, the net-of-tax interest rate in each country equals the rate of time preference of individuals or, in terms of previous notation, that in each country *i,*

$$\beta_t^{ii} = \left(1 - \rho_t^i\right)\left(1 - \sigma_t^i\right)\overline{r}_t^i = \overline{\theta} \qquad i = 1, 2$$

where $\overline{\theta}$ is the individual rate of time preference which is assumed to be constant and equal in the two countries.[21] From this rule, it is clear that in Ramsey-like models, domestic taxes have no long-run international effect. In these models, changes in the domestic source-based tax σ_t^i affect the net-of-tax return to home capital, and cause capital to move across borders, but this is a short-term effect. The long-run equilibrium level of capital abroad is given, in fact, by the modified golden rule that remains unchanged; thus, the equilibrium long-run level of capital is not affected by changes in the foreign tax rates. The residence-based tax rate ρ_t^i does not influence the international allocation of capital either, since the burden of residence taxation is independent of where savings are invested. It follows that in the Ramsey-type models domestic tax policies have no long-run international effect.[22]

In the previous model with overlapping generations, this problem does not emerge. In that model, first-period consumption differs from second-period consumption, thus the net-of-tax interest rate does not have to equal the rate of time preference. In this setting, changes in the domestic tax rates affect the interest rate and the individual saving behavior in each country, thereby influencing the international allocation of capital and economic growth. Depending on the individual saving functions, a tax change has different effects on the rate of growth, and these effects do not necessarily correspond to the impact on the international allocation of capital.

V. Conclusions

The model presented in this paper has shown how we can analyze the impact of domestic taxes on capital income in a context closer to what is observed in the real world. It considers

[20] Specifically, in these models, the Euler equation predicts a stable long-run positive relation between the net interest rate and economic growth; thus increases in taxation reduce the stock of domestic capital and also decrease the rate of growth.

[21] For discussion of the infinite-lived agent model, and references to the literature, see for example Blanchard and Fischer (1989). For specific applications to the case of open economies, see also Lejour and Verbon (1998).

[22] There will, however, be adjustments along the dynamics between stationary states as world savings adjust to new tax rates.

large countries, international capital mobility, economic growth, and generational savings as these aspects are necessary when examining the implications of domestic capital taxes in an integrated world economy. In doing so, the paper also explores the basic implications of using the overlapping-generations approach to examining the problem of capital income taxation in open economies.

The paper shows that the international effects of domestic taxes on capital income are less straightforward than is often supposed. We need to distinguish between the effect of domestic taxes on the international allocation of capital and their impact on the rate of economic growth. It is true, for example, that increasing domestic source taxes reduces the stock of domestic capital. But domestic taxation also influences capital accumulation (through saving), and the two effects are not necessarily similar. This conclusion clearly differs from the result one can derive in infinite-lived-agent models. An important distinction also exists between the growth and welfare effects of capital taxation. A tax change could increase the growth rate of domestic product, but it could lower national income which is related to residents' welfare. Indeed, the assessment of a tax policy critically depends on the evaluation criterion adopted.

These international tax interdependencies pose subtle problems of policy design to national governments. Governments may use taxes on capital income both to compete for the existing stock of world capital and to affect the rate of capital accumulation over time, and the choice of the tax policy depends on the government's objective. A policy that increases the domestic share of current capital may not increase the growth rate of that capital in the future. Clearly, this poses subtle issues as to the "best" way of taxing capital and the nature of Pareto-optimal tax rates.

I. Two-Country Model with Cobb-Douglas Utility and Production Functions

This appendix presents a simplified version of our two-country model of growth with Cobb-Douglas utility and production functions. This was used in Section 4 to examine the effect of taxes on capital income.

In presenting this simplified model, we first examine the optimizing behavior of consumers and firms, then consider the equilibrium in the world capital market and the law of capital accumulation for the two-country economy.

A. Consumers

The representative consumer in each country i has a Cobb-Douglas utility function

$$u^i = a \log c^i_{1t} + (1-a) \log c^i_{2t+1} + b \log \left(T - L^i_t\right) + \gamma \log G^i_{t+1}$$

where the time endowment T, the labor supply L^i_t, and the public good provision G^i_{t+1} are given with $L^i_t = L^i$, so that consumption decisions c^i_{1t} and c^i_{2t+1} are the only choice variables.

The consumer chooses lifetime consumption c^i_{1t} and c^i_{2t+1} so as to maximize his utility subject to the present value budget constraint

$$c^i_{2t+1} = \left[1 + \left(1 - \rho^i_{t+1}\right) R_{t+1}\right] \left(w^i_t L^i - c^i_{1t}\right)$$

In this special case, the solution to the consumer's maximization problem takes a very simple form. Applying the standard method of constrained optimization, we obtain:

$$\begin{aligned} c^i_{1t} &= a w^i_t L^i = (1-s) w^i_t L^i \\ S^i_t &= (1-a) w^i_t L^i = s w^i_t L^i \\ c^i_{2t+1} &= \left[1 + \left(1 - \rho^i_{t+1}\right) R_{t+1}\right] s w^i_t L^i \end{aligned}$$

where $s = 1 - a$ is the propensity to save wage income.

It may be noticed that, in this special case, saving is linear in the wage income. We assume for convenience that there is no population growth and normalize total population to one. Thus, individual and aggregate decisions coincide.

B. Firms

At any time t, competitive firms in each country i produce a homogenous output Y^i_t according to a constant return Cobb-Douglas production function in capital and labor

$$Y^i_t = \left[\left(A^i\right)^{\frac{1}{1-\epsilon}}\right]^{1-\epsilon} \left(K^i_t\right)^{\epsilon} \left(L^i\right)^{\vartheta} \qquad \text{with } \epsilon > 0, \vartheta < 1 \text{ and } i = 1, 2$$

with a productivity factor

$$A^i = \eta_i \left(K^i_t\right)^{\mu} \left(K^j_t\right)^{\mu^*} \qquad i, j = 1, 2 \text{ and } i \neq j$$

where $\mu + \mu^* = 1 - \epsilon$ and $\mu, \mu^*, \eta_i > 0$. Under these assumptions, returns to capital in each country are constant in the aggregate, thereby allowing unceasing economic growth to be possible. In particular, we have that

$$Y_t^i = \eta_i \left(L^i\right)^\vartheta \ \alpha_t^{\mu^*} K_t^i \qquad\qquad Y_t^j = \eta_j \left(L^j\right)^\vartheta \ \alpha_t^{-\mu^*} K_t^j$$

where $\alpha_t = \frac{K_t^j}{K_t^i}$ with $i, j = 1, 2$ and $i \neq j$.

In each country i, firms maximize profits $Y_t^i - w_t^i L^i - \overline{r}_t^i K_t^i$, and pay factors their marginal productivity. As a result, equilibria in national markets for capital and labor require that

$$\begin{array}{llll} & \textit{Country i} & & \textit{Country j} \\ \overline{r}_t^i & = \epsilon\eta_i \left(L^i\right)^\vartheta \alpha_t^{\mu^*} & & \overline{r}_t^j = \epsilon\eta_j \left(L^j\right)^\vartheta \alpha_t^{-\mu^*} \\ w_t^i & = (1-\epsilon)\,\eta_i \left(L^i\right)^\vartheta \alpha_t^{\mu^*} K_t^i & & w_t^j = (1-\epsilon)\,\eta_j \left(L^j\right)^\vartheta \alpha_t^{-\mu^*} K_t^j \end{array} \tag{A-1}$$

If we now substitute the equilibrium wage rates in the previous function for S_t^i and S_t^j, we obtain the expressions for national savings in each country

$$S_t^i = s\,(1-\epsilon)\,\eta_i \left(L^i\right)^{1+\vartheta} \alpha_t^{\mu^*} K_t^i \qquad\qquad S_t^j = s\,(1-\epsilon)\,\eta_j \left(L^j\right)^{1+\vartheta} \alpha_t^{-\mu^*} K_t^j$$

C. World Capital Market Equilibria and Accumulation

Equilibria in the world capital market require that national net rates of return to capital be equal (condition (8)). Using previous expressions for national returns $\overline{r}_{t+1}^i$, we have

$$R_{t+1} = r_{t+1}^i = \left(1 - \sigma_{t+1}^i\right) \epsilon\eta_i \left(L^i\right)^\vartheta \alpha_{t+1}^{\mu^*} = \left(1 - \sigma_{t+1}^j\right) \epsilon\eta_j \left(L^j\right)^\vartheta \alpha_{t+1}^{-\mu^*} = r_{t+1}^j \tag{A-2}$$

where $i, j = 1, 2$ and $i \neq j$.

Capital market equilibria also require that the sum of each country's capital stock equal the inherited level of world savings (condition (9)),

$$K_{t+1}^i + K_{t+1}^j = S_t^i + S_t^j \tag{A-3}$$

We can solve previous condition $(A-2)$ for the equilibrium capital ratio $\alpha_{t+1} = \frac{K_{t+1}^j}{K_{t+1}^i}$,

$$\alpha_{t+1} = \frac{K_{t+1}^j}{K_{t+1}^i} = \left(\frac{\eta_j \left(1 - \sigma_{t+1}^j\right) \left(L^j\right)^\vartheta}{\eta_i \left(1 - \sigma_{t+1}^i\right) \left(L^i\right)^\vartheta} \right)^{\frac{1}{2\mu^*}} = \alpha\left(\sigma_{t+1}^i, \sigma_{t+1}^j\right) \qquad i, j = 1, 2;\ i \neq j \tag{A-4}$$

This equation gives us the ratio α_{t+1} as a function of both countries' source tax rates. In particular, an increase in country i's source tax (with σ_{t+1}^j constant) leads to a shift of capital to country j and to a higher ratio α_{t+1}. In turn, this raises the pretax national return to capital $\overline{r}_{t+1}^i$, while the effect on the wage rate w_{t+1}^i is ambiguous (see equations $(A-1)$). However, if $\alpha_{t+1} > \frac{\mu^*}{1-\mu^*}$, then

w^i_{t+1} also raises.[23]

If we now substitute previous equation $(A-4)$ in the equilibrium condition $(A-2)$, we obtain the equilibrium world-wide return to capital

$$R_{t+1} = \epsilon \left[\eta_i \left(L^i\right)^{\vartheta} \left(1-\sigma^i_{t+1}\right)\right]^{\frac{1}{2}} \left[\eta_j \left(L^j\right)^{\vartheta} \left(1-\sigma^j_{t+1}\right)\right]^{\frac{1}{2}}$$

This expression tells us that, in equilibrium, the world-wide return to capital, R_{t+1}, depends only on the national source taxes. More specifically, an increase in national taxes lowers the equilibrium return to capital.

At this point, we can derive the law of capital accumulation in each country. In particular, we can substitute for S^i_t and S^j_t in $(A-3)$ and, using the fact that $K^j_{t+1} = \alpha_{t+1} K^i_{t+1}$, we obtain the accumulation equations

$$K^i_{t+1} = \frac{s\left(1-\epsilon\right)}{1+\alpha_{t+1}} \left(\eta_i \left(L^i\right)^{1+\vartheta} \alpha_t^{\mu^*} K^i_t + \eta_j \left(L^j\right)^{1+\vartheta} \alpha_t^{-\mu^*} K^j_t\right)$$

$$K^j_{t+1} = \alpha_{t+1} \frac{S^i_t + S^j_t}{1+\alpha_{t+1}} = \alpha_{t+1} \frac{s\left(1-\epsilon\right)}{1+\alpha_{t+1}} \left(\eta_i \left(L^i\right)^{1+\vartheta} \alpha_t^{\mu^*} K^i_t + \eta_j \left(L^j\right)^{1+\vartheta} \alpha_t^{-\mu^*} K^j_t\right)$$

where α_{t+1} and α_t are given by $(A-4)$. These equations give us the stock of capital in each country at time $t+1$, as a function of the inherited stocks of capital $\left(K^i_t, K^j_t\right)$ and national source taxes σ^i_{t+1} and σ^j_{t+1} (see equations (10))

If we confine the attention to symmetric countries, these equations greatly simplify, and give us:

$$\begin{aligned} \frac{K^i_{t+1}}{K^i_t} &= (1+g_i) = s\left(1-\epsilon\right)\left(L\right)^{1+\vartheta} \left(\frac{\alpha_t^{\mu^*} + \alpha_t^{1-\mu^*}}{1+\alpha_{t+1}}\right) \\ \frac{K^j_{t+1}}{K^j_t} &= (1+g_j) = \alpha_{t+1} s\left(1-\epsilon\right)\left(L\right)^{1+\vartheta} \left(\frac{\alpha_t^{\mu^*} + \alpha_t^{1-\mu^*}}{1+\alpha_{t+1}}\right) \end{aligned}$$

where, for simplicity, the terms η_i and η_j are normalized to be equal to one, and $L^i = L^j = L$. In this case, if symmetric countries levy constant and identical tax rates, then $\alpha_{t+1} = \alpha_t = 1$, so that they would grow at the same rate $g_i = g_j = g$.

It may be noticed that, in this model, there are no transitional dynamics and the economy is always at its balanced growth path. But, this path does not necessarily exist. To guarantee the existence of a balanced growth path, we need to impose some restrictions of the parameters of the model.

[23]To obtain this result, we need to re-write the wage rate in terms of total capital,

$$w^i_{t+1} = \left(1-\epsilon\right)\eta_i \left(L^i\right)^{\vartheta} \alpha_{t+1}^{\mu^*} \frac{\overline{K}_{t+1}}{1+\alpha_{t+1}}$$

If we differentiate this expression with respect to α_{t+1}, holding $\overline{K}_{t+1}$ constant, the result follows.

In particular, if countries are symmetric, an accumulation path with positive growth rate exists if $g > 0$, that is if $s\left(1-\epsilon\right)\left(L^{i}\right)^{1+\vartheta} > \frac{1+\alpha_{t+1}}{\alpha_t^{\mu^*}+\alpha_t^{1-\mu^*}}$. Throughout this paper, we have assumed that this assumption holds.

REFERENCES

Arrow, K.J., 1962, "The Economic Implications of Learning by Doing," *Review of Economic Studies*, Vol. 29, pp. 155-173.

Asea, P.K., and S.J. Turnovsky, 1998, "Capital Income Taxation and Risk-Taking in a Small Open Economy," *Journal of Public Economics*, Vol. 68, pp. 55-90.

Atkinson, A.B., and A. Sandmo, 1980, "Welfare Implications of the Taxation of Savings," *Economic Journal*, Vol. 90, pp. 529-549.

————, and E.J. Stiglitz, 1980, *Lectures on Public Economics*, McGraw-Hill, New York.

Azariadis, C., 1993, *Intertemporal Macroeconomics,* Blackwell, Oxford, United Kingdom, and Cambridge Massachusetts.

Barro, R.J., and X. Sala-I-Martin, 1992, "Public Finance in Models of Economic Growth," *Review of Economic Studies*, Vol. 59, pp. 645-661.

Bayoumi, T., D.T. Coe, and E. Helpman, 1999, "R&D Spillovers and Global Growth," *Journal of International Economics*, Vol. 47, pp. 399-428.

Bernheim, B.D., 2002, "Taxation and Saving," in *Handbook of Public Economics*, *ed. by* A.J. Auerback and M. Feldestein (eds), North-Holland, Amsterdam.

Bernstein J.I., and P. Mohnen, 1998, "International R&D Spillovers Between U.S. and Japanese R&D Intensive Sectors," *Journal of International Economics*, Vol. 44, pp. 315-338.

Bertola G., 1993, "Models of Economic Integration and Localized Growth," in *Adjustment and Growth in the European Monetary Union*, *ed. by* F. Torres and F. Giavazzi, Cambridge University Press, Cambridge.

Blanchard, O.J., and S. Fischer, 1989, *Lectures on Macroeconomics*, MIT Press, Cambridge, Massachusetts.

Bovenberg, A.L., 1986, "Capital Income taxation in Growing Open Economies," *Journal of Public Economics*, Vol. 31, 347-376..

Bucovetsky, S., and J.D. Wilson, 1991, "Tax Competition with Two Instruments," *Regional Science and Urban Economics*, Vol. 21, pp. 333-350.

Buiter, W.H., 1981, "Time Preference and International Lending and Borrowing in an Overlapping-Generations Model," *Journal of Political Economy*, Vol. 89, pp. 769-797.

————, and K.M. Kletzer, 1992, "Permanent International Productivity Growth Differentials in an Integrated Global Economy," *Scandinavian Journal of Economics*, Vol. 95, pp. 467-493.

Coe, D.T., and E. Helpman, 1995, "International R&D Spillovers," *European Economic Review*, Vol. 39, pp. 859-887.

Diamond, P.A., 1973, "Taxation and Public Production in a Growth Setting," in *Models of Economic Growth*, ed. by J.A. Mirrlees and A.H. Stern, MacMillan, London.

Ghosh, A.R., 1991, “Strategic Aspects of Public Finance in a World with High Capital Mobility,” *Journal of International Economics*, Vol. 30, pp. 229-247.

Gordon, R.H., 1983, “An Optimal Taxation Approach To Fiscal Federalism,” *Quarterly Journal of Economics*, Vol. 98, pp. 567-586.

Grossman, G.M., and E. Helpman, 1994, “Endogenous Innovation in the Theory of Growth,” *Journal of Economic Perspectives*, Vol. 8, pp. 23-44.

Ha, J., and A. Sibert, 1997, “Strategic Capital Taxation in Large Open Economies with Mobile Capital,” *International Tax and Public Finance*, Vol. 4, pp. 243-262.

Hall, R.E., 1988, “Intertemporal Substitution in Consumption,” *Journal of Political Economy*, Vol. 96, pp. 339-357.

Leahy, D., and J.P. Neary, 1999, “R&D Spillovers and the Case for Industrial Policy in an Open Economy,” *Oxford Economic Papers*, Vol. 51, pp. 40-59.

Lejour, A.M., and H.A.A.Verbon, 1997, “Tax Competition and Redistribution in a Two-Country Endogenous-Growth Model,” *International Tax and Public Finance*, Vol. 4, pp. 485-497.

————, 1998, “Source-Based Versus Residence-Based Capital Income Taxes in a Dynamic Model,” *European Journal of Political Economy*, Vol. 14, pp. 529-541.

Razin, A., and E.Sadka, 1991, “International Tax Competition and Gains From Tax Harmonization,” *Economics Letters*, Vol. 37, pp. 69-76.

Razin, A., and C.-W. Yuen, 1993, “Convergence in Growth Rates: The Role of Capital Mobility and International Taxation,” *CEPR Discussion Paper 760.*

————, 1996, “Capital Income Taxation and Long-Run Growth: New Perspectives,” *Journal of Public Economics*, Vol. 59, 239-263.

————, 1999, “Optimal International Taxation and Growth Rate Convergence: Tax Competition vs. Coordination,” *International Tax and Public Finance*, Vol. 6, pp. 61-78.

Romer, P.M., 1986, “Increasing Returns and Long-Run Growth,” *Journal of Political Economy*, Vol. 94, pp. 1002-1037.

Sibert, A., 1990, “Taxing Capital in a Large, Open Economy,” *Journal of Public Economics*, Vol. 41, pp. 297-317.

Turnovsky, S.J., 1996, “Fiscal Policy, Growth, and Macroeconomic Performance in a Small Open Economy,” *Journal of International Economics*, Vol. 40, pp. 41-66.

Uhlig, H., and N. Yanagawa, 1996, “Increasing the Capital Income Tax May Lead To Faster Growth,” *European Economic Review*, Vol. 40, pp. 1521-1540.

Wildasin, D.E., 1991, “Some Rudimentary ‘Duopoly’ Theory,” *Regional Science and Urban Economics*, Vol. 21, pp. 393-421.

Wilson J.D., 1986, “A Theory of Interregional Tax Competition,” *Journal of Urban Economics*, Vol. 19, pp. 296-315.

————, 1991, "Tax Competition with Interregional Differences in Factor Endowments," *Regional Science and Urban Economics*, Vol. 21, pp. 423-451.

————, 1999, "Theories of Tax Competition," *National Tax Journal*, Vol. 52, pp. 269-304.

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