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UNDERSTANDING THE “PROBLEM OF ECONOMIC DEVELOPMENT”: THE ROLE OF FACTOR MOBILITY AND INTERNATIONAL TAXATION*

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The “problem of economic development”, as Lucas (1988) states it, is the problem of accounting for the observed diversity in levels and rates of growth of per capita income across countries and across time. We study conditions under which capital mobility and labor mobility (two seemingly income-equalizing forces) may interact with cross-country differences in income tax rates and income tax principles (two seemingly income-diverging forces) to generate such diversity. As a corollary, we also examine when countries with different initial endowments may finally converge in their income levels.

I. Introduction

Spurred by Lucas’ (1988) seminal paper *“On the Mechanics of Economic Development,”* recent years have witnessed renewed and growing interests in the economics profession in the theory and evidence of economic growth. Factors that were considered as important sources of growth in the late 1950s and 1960s, such as technical change and population growth, continue to play an important role. But instead of being treated as exogenous factors, they are now modelled as outcomes from the optimizing decisions of the economic

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agents. [See, e.g., Romer (1990), and Becker et al. (1990).] On the other hand, more formal models are developed to incorporate other growth engines like human capital accumulation, product development, and trade that were emphasized in the descriptive literature of economic development. [See, e.g., Lucas (1988), Grossman and Helpman (1991), and Stokey (1991).] These models have been collectively called 'endogenous growth models', i.e., models that are capable of generating persistent growth without relying on exogenous forces.

Among the various driving forces for growth, *human* capital formation has received the most attention. This is in marked contrast to the significant role played by the accumulation of *physical* capital in the traditional Solow-Swan and Cass-Koopmans-type neoclassical growth models.[1] This shift in focus can be justified on both theoretical and empirical grounds. While Jones and Manuelli (1990), among others, have noted that output growth cannot be sustained through physical capital formation alone given diminishing marginal productivity of capital, Jorgenson and Fraumeni (1989) have also reported that human capital is quantitatively important relative to nonhuman capital as an income or wealth measure.

In order to understand the *problem of economic development* as posed by Lucas (1988), one has to look for ways to account for *"... the observed pattern, across countries and across time, in levels and rates of growth of per capita income ..."* in addition to pinning down the important factors that can generate and sustain income growth. Somehow, the literature has focused on disparities in growth patterns across countries rather than across time, and it is on these cross-country disparities that our paper will focus as well. Trivially, one can attribute the cross-sectional differences in growth experience to asymmetric preferences and/or technology, but this is generally unacceptable as a scientific explanation. Less trivially, one may also attribute the observed diversities to

[1] However, there has never been a neglect of the role of human capital in output growth. Growth accountants, like Denison (1974), have attributed a large fraction of economic growth in the US to improvement in the quality of labor services; while Uzawa (1965) and Razin (1972) have studied the accumulation of human capital in the Ramsey-type growth models.

country-specific shocks and adjustments. King and Rebelo (1993) have shown, however, that these growth differences cannot be rationalized and sustained as a *long term* phenomenon by *short run* (transitional) dynamics alone without producing extremely counterfactual implications.[2] Although the recent growth literature has been successful in explaining cross-country differences in (per capita) income *levels* in terms of different factor endowments, the explanation of differences in (per capita) income growth *rates* is a much harder challenge.[3]

Assuming that countries have identical preferences and technology but possibly different factor endowments, two major kinds of explanations have been provided. First, multiple steady states—economies with different initial endowments can evolve along the same equilibrium growth path, but in different directions, thus converging to different long-run positions;[4] or multiple equilibria—economies with the same initial endowment can follow different equilibrium growth paths and converge to different long run positions.[5] Second, differences in national, especially tax, policies—which have differential effects

[2]Their analysis is conducted in exogenous growth models. In principle, transitory changes are capable of generating permanent effects in models of endogenous growth. In other words, in the context of endogenous growth models, one can attribute persistent differences in income levels across countries to country-specific shocks. But as a matter of philosophy, it sounds odd to explain a regular pattern in terms of purely random factors.

[3]This is especially true in exogenous growth models, where the natural growth rate (being determined by an exogenous rate of technological progress) is an unalterable given.

[4]See, e.g., Becker et al. (1990) and Azariadis and Drazen (1990). Assuming that the private rate of return on human capital rises with the stock of human capital, Becker et al. obtain two stable steady states: one with large families and little human capital, and the other with small families and perhaps growing human and physical capital. They leave unanswered, however, the question of what produces diversity in long run growth rates within the groups of low-growth and high-growth countries separately. Growth diversity to a more widespread degree—in terms of the number of multiple stationary growth paths at various levels of income—is obtained in Azariadis and Drazen through increasing social returns to scale with local variations (what they called 'threshold externalities') in the accumulation of human capital.

[5]See, for instance, Benhabib and Perli (1994), where they show that, depending on the values of parameters (especially that of an externality parameter), there can exist a continuum of equilibria—not just continuum of balanced growth paths—in the Lucas (1988) model.

on the private agents' incentives to invest in growth-enhancing activities and hence the rates of productivity growth in different countries.[6] In this paper, we shall focus on this second, i.e., policy, explanation.

Most of these policy-growth studies have been conducted in the context of closed economies, where different countries are treated as isolated, non-interacting entities. With increasing global integration of the world economy, factor mobility opens a room for international policy spillovers, with policy changes in one country affecting resource allocation and growth in another country through changes in factor price differentials. In this paper, we would like to examine whether the tax-driven diversity in income growth rates can be preserved when (a) factors of production are freely mobile across national borders, and (b) the factor incomes earned in the foreign country are potentially subject to double taxation by both the home and foreign governments and are thus affected by both domestic and foreign tax policies. In particular, is factor mobility a growth-equalizing force and international income taxation a growth-diverging force? How do factor mobility and cross-country tax structures interact to determine growth differentials?

Similar issues have been addressed by Razin and Yuen (1996,1999). But in those two papers, we discuss only the role of capital mobility and international capital taxation. In this paper, we shall examine the role of labor mobility and international labor taxation as well. In particular, we shall try to distinguish between the effects of capital mobility and labor mobility. Although capital flows seem to be more prevalent and face less restrictions globally than labor flows, the latter is common among states within a federal system (such as the contiguous provinces in Canada, prefectures in Japan, and states in the US) and among neighboring countries with close economic and political ties (such

[6] See, e.g., Rebelo (1991) and Jones and Manuelli (1990) for a qualitative analysis, and King and Rebelo (1990), Lucas (1990a), Stokey and Rebelo (1995), and Mendoza et al. (1997) for a quantitative assessment, of the effects of tax changes on long run growth rates in models with capital formation (human and physical) as the source of growth. McGrattan and Schmitz (1998) examine the role of a wide range of policy variables in explaining cross-country income and growth differences.

as countries in the European Union). Labor flows are thus more relevant for regional growth. Among other things, we would like to know whether labor mobility and capital mobility are complements or substitutes as forces affecting growth? Are labor and capital flows symmetric in terms of their level and growth effects on incomes per capita?

Given the close connection between population growth and economic growth in the development process and as a broadening of the definition of the *problem of development*, we shall try to account for the observed diversity in the growth of (per capita and total) incomes as well as population. When population growth is determined exogenously, taxes can only affect income growth through the growth engine (say, human capital), with indistinguishable effects on the growth of per capita income and aggregate income. Endogenizing population growth will introduce a new channel through which taxes can affect per capita income growth and aggregate income growth differently. (See Appendix for more details.)

For the above reasons, we think that it is important to examine the interaction between taxation and (population and income) growth in the presence of factor mobility. To get some feel about the tax-growth relations across countries, we display in Table 1 the average effective tax rates on capital and labor income and the long run average annual growth rates of population and income across the G-7 countries.

The rest of the paper is organized as follows. Section II derives a fundamental relative growth condition and examines the growth-equalizing role of capital mobility and labor mobility. Section III provides an overview of two polar principles of international income taxation. The role of international factor income taxation in explaining the diverse growth performance across countries under different forms of factor mobility is analyzed in Section IV. Section V then examines a possible mechanism for income level convergence. A summary and some concluding remarks are contained in Section VI. Most of the results reported in this paper are model-free. We present a full-fledged model of endogenous growth (featuring both population and human capital growth) in a closed economy context in the Appendix. All the results in the paper can also

Table 1. Tax Rates and Growth Rates in the G-7 Countries

	Average tax rates (1965-88)		Average annual growth rates (1965-87)		
Country	Capital tax (%)	Labor tax (%)	population (%)	per capita GNP (%)	total GNP (%)
United States	43	25	1.00	1.5	2.50
United Kingdom	56	27	1.20	1.7	2.90
Germany	25	36	1.01	2.5	3.51
Italy	26	38	0.17	2.7	2.87
France	24	43	0.64	2.7	3.34
Japan	33	20	0.17	4.2	4.37
Canada	40	22	0.47	2.7	3.17

Sources: Tax rate figures are drawn from Mendoza, Razin, and Tesar (1994), and growth rate figures from the World Development Report (1989).

be derived more formally in an open economy extension of such model by incorporating capital and labor mobility and global taxation.

II. Growth Rate Convergence: The Role of Factor Mobility

It is well understood from standard trade theory that perfect factor mobility will lead to factor price equalization. In particular, capital mobility will equalize interest rates, whereas labor mobility will equalize wage rates, across countries. To assess the role of factor mobility in equalizing cross-country differences in output growth rates, we have to understand how factor price equalization is related to growth rate equalization. Their formal relation can be analyzed in a full-fledged dynamic general equilibrium model of endogenous growth such as an open economy extension of the autarky model laid out in the Appendix. Here in the main text, we shall focus only on those ingredients that are essential for understanding the fundamental relative growth condition (*) spelled out below.

Recall from the theory of saving that a consumer is allocating his consumption over time in a utility-maximizing way when s/he is equating her/

his intertemporal marginal rate of substitution (IMRS) to the interest rate (after adjusting for the relevant taxes), i.e.,

$$IMRS_{t\text{-}1,t} = \bar{r}_t, \tag{1}$$

between any two periods t-1 and t. Here, we are assuming for simplicity full depreciation of physical capital within one period and the absence of tax-deductibility of depreciation allowances. The reader can rest assured, though, that the essence of all the results in the remainder of the paper does not depend on this simplification; they will just be slightly complicated by the presence of the depreciation terms if we drop this assumption.

Suppose consumer preferences are isoelastic with some altruistic element as specified in the utility function below and as explained in fuller details in the Appendix:

$$\varphi \; {}^{4}_{t=0} \; \exists^t N_t^{>} \left(\frac{c_t^{1\text{-}\Phi}}{1-\Phi} \right),$$

where N_t is the size of the population (or the size of the representative dynastic family), c_t the consumption of the representative consumer, b the subjective discount factor, x the degree of interpersonal altruism, and s the inverse of the elasticity of intertemporal consumption substitution. In what follows, we shall loosely interpret the parameter x as reflecting consumer preference towards 'child quantity' and 1- s as reflecting consumer preference towards 'child quality'. Then we can rewrite equation (1) as

$$(1+g_{Nt})^{1->}(1+g_{ct})^{\Phi} = \exists \bar{r}_t, \tag{1'}$$

where the growth rate of any variable x between period t-1 and period t is defined as $g_{xt} = x_t / x_{t\text{-}1} - 1$. [Cf. The fundamental growth equation in Rebelo (1992).] Between any two countries A and B with symmetric preferences (i.e., same b, s, and x), their relative growth rates can be expressed as:

$$\left(\frac{1+g_{Nt}^{A}}{1+g_{Nt}^{B}}\right)^{1->}\left(\frac{1+g_{ct}^{A}}{1+g_{ct}^{B}}\right)^{\Phi} = \frac{\bar{r}_t^{A}}{\bar{r}_t^{B}}. \tag{1)"}$$

This relative growth condition (1)" will hold in any period $t > 0$ (i.e., in both the short run and the long run). In the long run when all economic variables are growing at constant rates, (1)" can be simplified further by imposing two *balanced growth* restrictions, viz., $g^i_c = g^i_y$ (i = A,B) and $g^A_Y = g^B_Y$. The first restriction says that per capita consumption (*c*) and per capita output (*y*) must grow at the same rate. It follows from the long run constancy of the consumption-output ratio. The second restriction says that aggregate output growth rates must be equal across countries. It follows from the requirement that the net trade balance (resulting from either capital flows or labor flows) between any two countries grow at the same rate as their respective GDPs along the global long run steady state growth path, which is in turn a direct consequence of the long run constancy of the trade balance-GDP ratio in all countries. Since aggregate income (*Y*) is the product of per capita income (*y*) and population (*N*) so that $g_Y = (1+g_N)(1+g_y) - 1$, this second restriction implies that $(1+g^A_N)(1+g^B_N) = (1+g^B_y)(1+g^A_y)$.[7] Applying these two restrictions to (1)", we obtain the fundamental relative growth condition:

$$\left(\frac{1+g_{y}^{A}}{1+g_{y}^{B}}\right)^{>-(1-\Phi)} = \frac{\bar{r}^{A}}{\bar{r}^{B}}. \tag{*}$$

[7] Among other things, it implies that countries with lower population growth will enjoy faster growth in their per capita incomes. See Razin and Yuen (1997a) for supportive evidence on this and other related empirical implications. In a multi-country world, it is possible for aggregate output growth to diverge across blocs of countries that are not interconnected by factor mobility (i.e., when net capital and/or labor flows exist only among countries within each bloc, but not across blocs). But within each bloc (where factor mobility is effectively at work), this total income growth equalization result will still apply -and it is around this scenario that our analysis is built.

We shall exploit this condition to derive all the important results in the rest of the paper.

A. The Role of Capital Mobility

Under perfect capital mobility, capital will flow from capital-rich or low-MPK (marginal product of capital) countries to capital-poor or high-MPK countries. Given the law of diminishing returns, these cross-border capital flows will ultimately equalize the MPKs or rates of return on capital in all countries that are interconnected by capital mobility.[8] In the absence of taxes, therefore, $\bar{r}^A \backepsilon \bar{r}^B$, which (from (*)) implies that $g^A_y = g^B_y$. Nonetheless, this growth rate convergence is only a necessary, but not sufficient, condition for convergence in per capita income levels. For countries that start off from different levels of initial income (due perhaps to cross-country differences in initial endowments of human and/or physical capital), their absolute income levels will still diverge (although their relative income levels will remain constant) in spite of identical long run rates of income growth.

B. The Role of Labor Mobility

As Razin and Sadka (1997) make clear in their survey paper, *"... [w]ith identical constant returns to scale technologies everywhere and two factors (capital and labor), it suffices that one factor is freely mobile to equalize the marginal product of each factor everywhere ..."* It follows that wage rate (or marginal product of labor, MPH) equalization brought about by labor mobility will also be accompanied by equalization of interest rates (or MPKs) whether or not capital is internationally mobile. As a result, we again have

[8]Such rate-of-return equalization will be immediate if capital stocks (both existing and new) can be moved from one country to another costlessly. In a more realistic setting where old capital is movable only at a high cost and/or where new capital investment involves adjustment costs, the equalization will be slow and gradual.

$\bar{r}^A \backepsilon \bar{r}^B$ (in the absence of taxes), implying $g^A_y = g^B_y$ from (*), i.e., growth rate convergence.

In other words, under constant returns to scale technology, capital mobility and labor mobility play a symmetric role in equalizing income growth rates across countries without any necessary implications for income level convergence.[9] One may wonder why, as equation (*) suggests, interest rate equalization implies equalization of per capita output growth rates. To understand this, one has to understand two basic relations. First, the rate of growth of per capita income (g_y) is identical to the rate of growth of human capital (g_h), i.e., human capital is *the* engine of growth. Second, the interest rate (r, representing the rate of return on physical capital investment) has to be equal to the rate of return on human capital investment (r_h). The first is a balanced growth relation that holds in the long run under constant returns to scale production technologies, and the second is a no-arbitrage relation between the two kinds of capital investment. Since the rate of return on human capital (r_h) governs how fast one would like to invest in her/his human capital (i.e., g_h), these two relations ($g_y = g_h$ and $r = r_h$) together imply a one-to-one correspondence between interest rate equalization and growth rate equalization.

So far, our analysis of growth rate convergence has abstracted from cross-country diversity in income taxes that may give rise to factor price (interest rate and/or wage rate) differentials even in the presence of factor mobility. As we shall see, whether tax differences will drive a wedge in factor prices will depend on the tax treatment of the foreign-source factor income earned

[9] Absent adjustment costs, factor price equalization, hence growth rate convergence, will occur immediately following the open-up of the national borders for capital and/or labor flows. In addition to the normal case that involves positive net flows of capital and/or labor, one may wonder whether two extreme cases will arise, i.e., (a) all capital or workers in the world reside in one single country, and (b) no cross-border capital flows or labor flows take place (i.e., back to autarky). Theoretically, one can rule out case (a) by imposing the Inada conditions and case (b) by assuming some fundamental cross-country heterogeneity (such as differences in initial stocks of human and/or physical capital). Empirically, these two extreme cases can be dismissed as uninteresting and irrelevant.

by domestic factors of production -by both the domestic and foreign governments. In other words, it depends on the principle of international income taxation adopted (or tax agreements reached) by their tax authorities. It is to this particular issue that we now turn.

III. Principles of International Income Taxation

Two common principles of international income taxation are the *residence* (or *worldwide*) principle and the *source* (or *territorial*) principle. The residence principle uses the place of residency of the taxpayer as the basis for the assessment of tax liabilities. The source principle employs the source of income as the basis for assessing tax liabilities.[10]

Let us use τ^i_{qD} to denote the tax rate on the domestic-source *q*-income (q = w,r) of residents of country *i*, τ^i_{qN} the tax rate on the *q*-income earned by non-residents in country *i*, and τ^i_{qF} the tax rate on the foreign-source *q*-income of country *i* residents on top of their non-residents' taxes paid to the foreign government net of the domestic tax credit or deduction granted by country *i* government. The mnemonics are such that 'D' stands for domestic-source, 'F' for foreign-source, and 'N' for non-residents. All these three tax rates are levied by the country *i* government. The after-tax rate of return on capital in country *i*, $\bar{r}^i$, equals $(1 - \tau^i_{rD})r^i$ if capital is invested at home, and $[1 - \tau^i_{rF} - (1 - \alpha^i_r)\tau^j_{rN}]r^j$ if capital is invested abroad (in country *j*). In the general case where the credit rate, α^i_r, lies between zero and one, we have a partial *credit* system whereby part of the tax paid abroad is deducted from the tax liability in the home country. It can be interpreted as a full credit system when $\alpha^i_r = 1$ and $\tau^j_{rN} \leq \tau^i_{rF}$ and as a full deduction system

[10] For details, see Frenkel et al. (1991).

when $a^i_r = t^i_{rF}$.[11] With international capital mobility between countries A and B, the absence of net-of-tax arbitrage possibilities across investment locations imply

$$(1-\vartheta^A_{rD})r^A = [1-\vartheta^A_{rF}-(1-a_r^A)\vartheta^B_{rN}]r^B, \text{ and} \quad (2A)$$

$$(1-\vartheta^B_{rD})r^B = [1-\vartheta^B_{rF}-(1-a_r^B)\vartheta^A_{rN}]r^A. \quad (2B)$$

A similar set of arbitrage conditions across work locations holds for labor income taxation under international labor mobility, with r replaced by w, i.e.,

$$(1-\vartheta^A_{wD})w^A = [1-\vartheta^A_{wF}-(1-a_w^A)\vartheta^B_{wN}]w^B, \text{ and} \quad (3A)$$

$$(1-\vartheta^B_{wD})w^B = [1-\vartheta^B_{wF}-(1-a_w^B)\vartheta^A_{wN}]w^A. \quad (3B)$$

Under the pure residence principle, residents are taxed on their worldwide income uniformly regardless of their source of income, while non-residents are not taxed at all. Under capital mobility, this implies that $t^i_{rD} = t^i_{rF}$ and $t^i_{rN} = 0$ (and a^i_r becomes irrelevant). From equations (2A) and (2B), it follows that $r^A = r^B$, i.e., equalization of the pre-tax interest rates (or MPK's), hence efficiency in the global allocation of investment. Similarly, the residence principle implies equalization of pre-tax wage rates -i.e., $w^A = w^B$- hence efficiency in the global allocation of labor under labor mobility.

[11]Without any credit and deduction, the after-tax rate of return on capital invested abroad (in country *j*) is $(1-t^i_{rF}-t^j_{rN})r^j$. Under the full *credit* system, whereby taxes paid abroad are fully deducted from the tax liabilities in the home country, it becomes $(1-t^i_{rF})r^j$. The *deduction* system, whereby the tax paid abroad is deducted from taxable income in the home country, provides an alternative relief from double taxation. In that case, the after-tax rate of return on capital invested abroad (in country j) should be written as $(1-t^i_{rF})(1-t^j_{rN})r^j$. All the qualitative results in this paper are valid for both the credit and deduction systems.

Under the pure source principle, all types of income originating in the country are taxed uniformly regardless of the place of residency of the income recipients. With capital mobility, we have, $\tau^i_{rD} = \tau^i_{rN}$ and either $\tau^i_{rF} = a^i_r = 0$ or $\tau^i_{rF} = a^i_r \tau^j_{rN}$. From equations (2A) and (2B), this implies $(1 - \tau^i_{rD}) r^i = (1 - \tau^j_{rD}) r^j$ (i = A,B; j = B,A), i.e., equalization of the post-tax interest rates (or IMRS's), hence efficiency in the global allocation of savings. Similarly, the source principle implies equalization of post-tax wage rates -$(1 - \tau^i_{wD}) w^i = (1 - \tau^j_{wD}) w^j$ (i = A,B; j B,A)- hence efficiency in the global allocation of household time under labor mobility.

IV. Interaction between Factor Mobility and International Income Taxation

A. The Role of Capital Mobility and International Capital Income Taxation

This is a case we have analyzed in an earlier paper (Razin and Yuen, 1996). In order to facilitate the comparison with the case of labor mobility and to build intuition behind the results derived below, let us revisit it here. When capital is mobile, the choice of international tax principle and tax rates levied on capital incomes earned by residents and non-residents at home and abroad will affect the after-tax rates of return on capital ($\bar{r}$) and, indirectly, the long run rates of growth of per capita income (g_y) across countries through the fundamental growth condition (*). Applied to two open economies A and B, we have

$$\left(\frac{1+g_y^A}{1+g_y^B}\right)^{> (1-\Phi)} = \frac{\bar{r}^A}{\bar{r}^B} = \frac{(1-\vartheta^A_{rD})r^A}{(1-\vartheta^B_{rD})r^B} = \frac{1-\vartheta^A_{rD}}{1-\vartheta^B_{rF}-(1-a^B_r)\vartheta^A_{rN}}, \qquad (*)'$$

where use has been made of the interest arbitrage condition for country B residents (2B) to arrive at the last equality. This equation shows how the relative income growth rates in A and B depend on the capital tax rates in the two countries and the relative bias in preference towards quantity versus quality of children (ξ versus $1 - \sigma$).

Recall that, under perfect capital mobility, the no-arbitrage restrictions will force the after-tax rates of return on capital ($\bar{r}$'s) to be equalized across countries under the *source* principle. Equation (*)' therefore implies convergence in income growth rates if the *source* principle prevails (i.e., when $\tau^A_{rN} = \tau^A_{rD}$ and either $\tau^B_{rF} = \alpha^B_r = 0$ or $\tau^B_{rF} = \alpha^B_r \tau^A_{rN}$). Under the alternative *residence* principle (i.e., when $\tau^B_{rF} = \tau^B_{rD}, \tau^A_{rN} = 0$, and α^B_r becomes irrelevant), since the after-tax interest rates are not equalized by capital mobility, asymmetry in $\bar{r}$'s (due to the asymmetry between τ^A_r and τ^B_r) implies, in turn, asymmetry in growth rates.

Equation (*)' also indicates that under residence-based taxation, when $\xi \neq 1 - \sigma$, asymmetric tax rates may have differential effects on income growth. In particular, when people are more biased towards quality rather than quantity of children ($\xi < 1 - \sigma$), the country with a higher capital tax rate will exhibit faster growth in per capita income. Given that growth in aggregate income will be equalized across countries in the long run, this implies slower growth in population. The reverse is true when people are more biased towards quantity than quality ($\xi > 1 - \sigma$).[12] The intuition is similar to that given in the closed economy example in the Appendix. Other things equal, the country with a higher capital tax rate will have less incentive to invest in physical capital and more to invest in either child quality if $\xi < 1 - \sigma$ or in child quantity if $\xi > 1 - \sigma$. We summarize these results in the following proposition.

[12]The tax rate τ_r, rather than the after-tax MPK, matters here because the cross-country MPKs will be equalized under the residence principle anyway.

Proposition 1 (P1): International Capital Taxation and Relative Growth[13]

(a) When both countries adopt the source principle, $g_y^A = g_y^B$ *and* $g_N^A = g_N^B$ *if* $\xi \neq 1 - \sigma$ *irrespective of international tax differences;*

(b) When both countries adopt the residence principle, two cases are possible:

i) if $\xi > 1 - \sigma$, $g_y^A \overset{\geq}{<} g_y^B$ *and* $g_N^A \overset{\leq}{>} g_N^B$ *as* $\tau^A_{rD} \overset{\leq}{>} \tau^B_{rD}$*; and*

ii) if $\xi < 1 - \sigma$, $g_y^A \overset{\leq}{>} g_y^B$ *and* $g_N^A \overset{\geq}{<} g_N^B$ *as* $\tau^A_{rD} \overset{\leq}{>} \tau^B_{rD}$.

While asymmetry in tax rates can induce differential growth rates when both countries adopt the residence principle, we note that the adoption of asymmetric international tax principles (with or without asymmetry in tax rates) by different countries can also generate disparity in growth rates.[14]

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[13]In the special case where $\xi = 1 - \sigma$, the representative agent is 'justly altruistic', i.e., the dynastic family can be viewed as one single person so that transferring consumption from one family member to another will not change the utility of any family member. In this case, as they substitute out of physical capital investment following a rise in the capital income tax, they will be indifferent between substituting into investment in child quality and substituting into investment in child quantity. As a result, we can show by using (*)' that aggregate consumption growth will *always* be equalized across countries irrespective of cross-country tax differences under the source principle and may differ across countries depending on tax differences under the residence principle. More formally, $(1+g^A_{Nt})(1+g^A_{ct}) = (1+g^B_{Nt})(1+g^B_{ct})$ for all $t > 0$ under the source principle, and $(1+g^A_{Nt})(1+g^A_{ct}) \overset{\geq}{<} (1+g^B_{Nt})(1+g^B_{ct})$ as $\tau^A_{rDt} \overset{\leq}{>} \tau^B_{rDt}$ for all $t > 0$ under the residence principle. Notice that these results apply to the *whole* dynamic growth path (i.e., both the short run and the long run). To ensure the existence of balanced growth under source-based taxation, however, we have to impose a restriction, i.e., $\tau^A_{rD} = \tau^B_{rD}$, so that $(1+g^A_N)(1+g^A_c) = (1+g^B_N)(1+g^B_c)$ in the long run. This restriction is not required under residence-based taxation, though.

[14] When country A adopts the pure residence principle (with full deduction) and country B adopts the pure source principle, for instance, there are again two cases to consider: (i) $g^A_y \overset{\geq}{<} g^B_y$ and $g^A_N \overset{\leq}{>} g^B_N$ as $\tau^A_{rD} \overset{\leq}{>} 0$ if $\xi > 1 - \sigma$; and (ii) $g^A_y \overset{\leq}{>} g^B_y$ and $g^A_N \overset{\geq}{<} g^B_N$ as $\tau^A_{rD} \overset{\leq}{>} 0$ if $\xi < 1 - \sigma$. In the special case where $\xi = 1 - \sigma$, we have $(1 + g^A_{Nt})(1 + g^A_{ct}) \overset{\geq}{<} (1+g^B_{Nt})(1+g^B_{ct})$ as $\tau^A_{rDt} \overset{\leq}{>} 0$ for all $t > 0$. But a restriction, $\tau^A_{rD} = 0$, has to be imposed

Note also from equation (*)' that, in cases intermediate between the pure source and pure residence principles (i.e., with partial credit or deduction of taxes on foreign-source capital income to be paid to the domestic and/or foreign governments), the relative magnitudes of the tax wedges $(1\text{-}t^{i}_{rD})$ and $[1 - t^{j}_{rF} - (1 - a^{j}_{r})\, t^{i}_{rN}]$ (i = A,B; j = B,A) matter. In those cases, it will also be important to distinguish between the differential growth effects of the two alternative forms of relief from double taxation, i.e., the credit system and the deduction system.

Proposition 1 characterizes the tax effects on relative growth due to the international tax system and the relative bias in preference between quantity and quality of children. In reality, the residence principle is the dominant tax principle widely adopted by most industrial countries for the taxation of capital income. The popularity of residence-based taxation may be explained by its production efficiency, Ramsey (second best) efficiency, and capital export neutrality implications.[15] From (P1b), we can thus conclude that international asymmetry in capital taxes is a plausible explanation for the diversity in growth rates. A closer examination of the

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(implying $(1 + g^{A}_{N})\,(1 + g^{A}_{y}) = (1+g^{B}_{N})\,(1+g^{B}_{y})$ in order to ensure the existence of balanced growth if $x = 1 - s$. In this scenario (irrespective of the relative magnitudes of x and $1 - s$), residents of country A will always earn a lower after-tax rate of return—by a factor of $(1\text{-}t^{A}_{rD})$—than will residents of country B irrespective of their locations of investment unless the capital tax rate in A is negative. Residents of country A will earn $(1\text{-}t^{A}_{rD})r^{A}$ at home and $(1\text{-}t^{A}_{rF})\,(1\text{-}t^{B}_{rN})r^{B}$ abroad, and residents of country B will earn $(1\text{-}t^{B}_{rD})r^{B}$ at home and r^{A} abroad. No arbitrage ensures that $(1\text{-}t^{B}_{rD})r^{B} = r^{A}$ for residents of both countries. That explains why, here, the sign of t^{A}_{rD} rather than the relative size of t^{A}_{rD} and t^{B}_{rD} determines the relative growth rates of population and per capita consumption in the two countries. Although the details of the results here have to be modified if the residence principle is applied by country A with full or partial credit or partial deduction instead, this example serves to illustrate the somewhat weird possibility of growth rate convergence even when countries adopt different tax principles and different tax rates (say, when $t^{A}_{rD} = 0$ and $t^{B}_{rD} > 0$).

[15]See Frenkel et al. (1991) and Razin and Yuen (1999) for a discussion of these implications of the residence principle.

relation between capital taxes on the one hand and income and population growth rates on the other seems to suggest that $\xi > 1 - \sigma$ conforms to the situation in these countries. In other words, low capital tax rates tend to be associated with faster growth in per capita income and slower growth in population. [See Razin and Yuen (1996).]

B. The Role of Labor Mobility and International Labor Income Taxation

Under perfect labor mobility, the absence of arbitrage opportunities ensures the equalization of after-tax wage rates for any worker who can choose to work in either country. In particular, the two wage arbitrage conditions (3A) and (3B) hold, i.e., $(1-\tau^i_{wD})w^i = [1 - \tau^i_{wF} - (1 - a^i_w)\tau^j_{wN}]w^j$ (i = A,B; j = B,A). To determine whether international income growth rates will be equalized by labor mobility, we have to first figure out what these two conditions imply about interest rate equalization and then use the fundamental relative growth condition (*) to derive their implications for growth rate convergence.

In perfectly competitive markets, profit-maximizing firms will always hire capital and labor by equating their prices to their respective marginal products. In other words, $r^i = MPK^i$ *and* $w^i = MPH^i$. To determine a more precise relation between MPK^i and MPH^i, let us suppose (as in the closed economy example in the Appendix) that the aggregate production function takes the Cobb-Douglas form, i.e.,

$$Y = AK^{\varepsilon} H^{1-\varepsilon} ,$$

where Y is aggregate output, K the aggregate capital stock, H total effective labor, A (>0) the production coefficient, and $\varepsilon \in (0,1)$ the output share of capital. Suppose further that all countries face the same technology, i.e., identical production parameters (A, ε). Then one can easily show that the relative capital-labor ratios, $(K^i/H^i)/(K^j/H^j)$, can be expressed as either

$(MPK^{j}/MPK^{i})^{1/(1-e)}$ or $(MPH^{i}/MPH^{j})^{1/e}$, i.e., $(r^{j}/r^{i})^{1/(1-e)} = (w^{i}/w^{j})^{1/e}$. Combined with the wage arbitrage condition (3A) and applied to any two economies A and B, this implies that

$$\frac{r^B}{r^A} = \left(\frac{w^A}{w^B}\right)^{(1-,)/,} = \left(\frac{1-\vartheta^A_{wF}-(1-a^A_w)\vartheta^B_{wN}}{1-\vartheta^A_{wD}}\right)^{(1-,)/,} \quad / \quad 7^{AB}.$$

Substituting this into the fundamental relative growth condition (*), we obtain

$$\left(\frac{1+g^A_y}{1+g^B_y}\right)^{>(1-\Phi)} = \frac{\bar{r}^A}{\bar{r}^B} = \frac{(1-\vartheta^A_{rD})r^A}{(1-\vartheta^B_{rD})r^B} = \frac{1-\vartheta^A_{rD}}{(1-\vartheta^B_{rD})7^{AB}}. \qquad (*)\text{”}$$

Note that $t^A_{wD} = t^A_{wF}$, $t^B_{wN} = 0$, and a^A_w becomes irrelevant (implying $L^{AB} = 1$) under the residence principle, and $t^B_{wN} = t^B_{wD}$ and either $t^A_{wF} = a^A_w = 0$ or $t^A_{wF} = a^A_w t^B_{wN}$ (implying $L^{AB} \gtrless 1$ as $t^A_w \gtrless t^B_w$ under the source principle. The proposition below should be transparent.

Proposition 2 (P2): International Labor Taxation and Relative Growth [16]

(a) When both countries adopt the source principle, two cases are possible:

i) if $x > 1-s$, $g^A_y \gtrless g^B_y$ and $g^A_N \lesseqgtr g^B_N$ as $W^A \gtrless W^B$; and

ii) if $x < 1-s$, $g^A_y \lesseqgtr g^B_y$ and $g^A_N \gtrless g^B_N$ as $W^A \gtrless W^B$

where the weighted tax wedge is defined as $\Sigma^i \equiv (1-\vartheta^i_r)^{,}(1-\vartheta^i_w)^{1-,}$.

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[16] We require $W^A = W^B$ in case (a) and $t^A_{rD} = t^B_{rD}$ in case (b), so $(1+g^A_N)(1+g^A_y) = (1+g^B_N)(1+g^B_y)$, for the existence of balanced growth if $x = 1 - s$.

(b) When both countries adopt the residence principle, two cases are possible:

i) *if* $\xi > 1-\sigma$, $g^A_y \gtrless g^B_y$ *and* $g^A_N \lessgtr g^B_N$ *as* $\tau^A_{rD} \lessgtr \tau^B_{rD}$ *; and*

ii) *if* $\xi < 1-\sigma$, $g^A_y \lessgtr g^B_y$ *and* $g^A_N \gtrless g^B_N$ *as* $\tau^A_{rD} \lessgtr \tau^B_{rD}$.

Contrary to what we find in the capital mobility case, (P2a) shows that the source principle is not necessarily growth-equalizing. Although the post-tax MPH's are equalized under territorial taxation, the post-tax MPK's are not unless the weighted tax wedges (Ω's) are uniform across countries. So, in contrast to (P2a), wage tax asymmetry matters here as much as interest tax asymmetry. Like (P1b), though, (P2b) implies that asymmetry in capital tax rates under worldwide taxation can be a source of growth disparity. As before, we can show that asymmetry in the international income tax principle (with or without asymmetry in tax rates) can be yet another source of growth rate differences.[17]

C. The Role of Capital cum Labor Mobility and International Income Taxation

What happens when both capital and labor can freely move across national borders to take advantage of factor price differentials? We understand from the preceding analysis that, in equilibrium, capital mobility implies equal after-tax interest rates from the perspectives of capital owners in each country, irrespective of the location of their investment. Similarly, labor mobility implies equal after-tax wage rates from the perspective of workers,

[17] When country A adopts the residence principle and country B adopts the source principle, $g^A_y \gtrless g^B_y$ and $g^A_N \lessgtr g^B_N$ as $(1-\tau_r^A)^\varepsilon \gtrless (1-\tau_r^B)$ if $\xi > 1-\sigma$, whereas $g^A_y \lessgtr g^B_y$ and $g^A_N \gtrless g^B_N$ as $(1-\tau_r^A)^\varepsilon \gtrless (1-\tau_r^B)$ if $\xi < 1-\sigma$. We require $(1-\tau_r^A)^\varepsilon = (1-\tau_r^B)$, so $(1+g^A_N)(1+g^A_y) = (1+g^B_N)(1+g^B_y)$, for the existence of balanced growth if $\xi = 1-\sigma$.

irrespective of their work location. These two no-arbitrage conditions can be expressed as

$$\frac{K^i}{H^i} = \left(\frac{1-\vartheta^i_{rF}-(1-a^i_r)\vartheta^j_{rN}}{1 \quad \vartheta^j_{rD}}\right)^{1/(1-,\ )}\left(\frac{K^j}{H^j}\right),\ and$$

$$\frac{K^i}{H^i} = \left(\frac{1-\vartheta^j_{wD}}{1-\vartheta^j_{wF}-(1-a^j_w)\vartheta^i_{wN}}\right)^{1/,}\left(\frac{K^j}{H^j}\right).$$

Together, they imply the following viability conditions

$$(1-\vartheta^i_{rD})^{,}(1-\vartheta^i_{wD})^{1-,} = [1-\vartheta^i_{rF}-(1-a^i_r)\vartheta^j_{rN}]^{,}[1-\vartheta^i_{wF}-(1-a^i_w)\vartheta^j_{wN}]^{1-,},$$

$i = A,B;\ j = B, A.$

Again, one can examine the possibility of growth rate convergence under different international tax principles. Instead of considering the various possible cases one by one, we shall focus on a case of realistic interest, i.e., when the source principle is applied to labor income taxation and the residence principle to capital income taxation. Under source-based labor taxation, $t^i_{wD} = t^i_{wN}$ and either $t^i_{wF} = a^i_w = 0$ or $t^i_{wF} = a^i_w t^i_{wN}$. Under residence-based capital taxation, $t^i_{rD} = t^i_{rF}$ and $t^i_{rN} = 0$ (a^i_r irrelevant). Substituting these conditions into the viability conditions above reduces them down to one single restriction, viz., $t^A_w = t^B_w$, implying that $L^{AB} = 1$. Imposing this restriction on the relative growth condition (*)" yields

$$\left(\frac{1+g^A_y}{1+g^B_y}\right)^{>(1-\Phi)} = \frac{\bar{r}^A}{\bar{r}^B} = \frac{1-\vartheta^A_{rD}}{1-\vartheta^B_{rD}}. \qquad (*)'''$$

Hence, the following proposition.

Proposition 3 (P3): International Taxation and Relative Growth under Capital cum Labor Mobility [18]

When both countries adopt the residence principle for capital income taxation and the source principle for labor income taxation, two cases are possible:

i) *if* $\xi > 1-\sigma$, $g^A_y \gtrless g^B_y$ *and* $g^A_N \lessgtr g^B_N$ *as* $\tau^A_{rD} \lessgtr \tau^B_{rD}$; *and*

ii) *if* $\xi < 1-\sigma$, $g^A_y \lessgtr g^B_y$ *and* $g^A_N \gtrless g^B_N$ *as* $\tau^A_{rD} \lessgtr \tau^B_{rD}$.

Proposition 3 suggests that applying different international income tax principles to different kinds of income can be another source of growth diversity under free mobility of both factors of production only if the capital income tax rates are also different across countries. The results look very similar to those stated in (P1b), i.e., capital taxation under the pure residence principle. This is due to two reasons: (a) as we have seen in Section II, under constant returns technology and in the absence of taxes, capital mobility and labor mobility are perfect substitutes in terms of factor price equalization; and (b) the viability conditions under capital cum labor mobility do not permit wage tax asymmetry across countries, so that only interest tax asymmetry matters here.

V. Income Level Convergence

So far, we have considered only growth rate convergence, which may or may not be accompanied by convergence in income levels. Obviously, the various scenarios we have analyzed that may give rise to growth rate divergence will also result in income level divergence. Although the recent evidence on the convergence of incomes across countries is mixed,[19] it is interesting to

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[18] Again, if $\xi = 1-\sigma$, we have to impose the restriction $\tau^A_{rD} = \tau^B_{rD}$, so $(1+g^A_N)(1+g^A_y) = (1+g^B_N)(1+g^B_y)$, in order to ensure the existence of balanced growth.

[19] See, e.g., Barro and Sala-i-Martin (1992) and Ben-David (1995).

examine the conditions under which international diversity in income levels can be eliminated.

Recall from Section II that, under a constant returns to scale technology, capital mobility and labor mobility will play a symmetric role in equalizing income growth rates across countries without any necessary implications for income level convergence. This conclusion is based on the implicit assumption that physical capital and human capital are two symmetric factors of production. However, it has been widely accepted that the 'human nature' involved in the accumulation of human capital makes it quite different from the accumulation of physical capital. Among other things, one feature of human capital investment that distinguishes it from physical capital investment is that it is a *social* activity involving *groups* of people, that an individual's effort to raise her/his knowledge and skills may end up benefitting other members of the society through group interactions. In short, investment in human capital involves an external productivity or spillover effect. Lucas (1988,1990b) models these knowledge spillovers in the form of a dependence of aggregate output on the economy-wide average level of human capital ($\bar{h}$) through an externality parameter (ẽ) in addition to its dependence on the capital and labor inputs i.e., these externalities generate some form of increasing returns. The production function is modified as follows:

$$Y = AK^{,} H^{1\,,} \bar{h}^{\tilde{,}} .$$

This externality feature of human capital has been exploited by Lucas (1990b) to resolve the puzzle why capital does not flow from rich to poor countries to take advantage of rate-of-return benefits. Assuming these spillover effects to be somehow confined within national boundaries, we (Razin and Yuen, 1997b) have also used it to show how, unlike capital mobility, labor mobility can serve as an income-equalizing force by providing a channel for the transmission of these external effects across countries/regions.

The idea behind our income level convergence result is simple and intuitive. Under labor mobility, workers will move from low-wage (human-capital-poor) countries to high-wage (human-capital-rich) countries. By mingling themselves with more knowledgeable/skillful workers in the high-wage country, migrants or guest workers will enjoy an upward shift in their wage profile. Through wage arbitrage, 'those left behind' in the low-wage country will also experience higher wage profiles. This will give them incentive to increase their rate of human capital investment. In this sense, we can view the migrant workers as 'messengers' of technological progress, transmitting the more advanced knowhow from the foreign country to their home country. Over time, this transmission mechanism will lead to equalization in the levels of human capital and income per capita among economies interlinked by labor mobility.

This level convergence result, which also implies growth rate convergence, does not mean that cross-country differences in income tax rates can never give rise to international diversity in income growth. Since the result is a manifestation of long run behavior, all it means is that *balanced growth* may not exist in the presence of tax asymmetry when knowledge spillovers (or increasing returns) are prevalent. Evidently, when the economies fail to converge to their steady state growth paths because of such tax asymmetry, their income levels and growth rates will generally diverge as well. Put differently, tax harmonization is generally required for level convergence.

VI. Conclusion

Let us first summarize the answers to the several questions posed in the introduction, and then make some concluding remarks. First, factor (both capital and labor) mobility is found to be a driving force that will equalize *aggregate* income growth rates, but not necessarily *per capita* income growth rates, in the long run. The latter differences may persist due to, say, cross-country differences in income tax rates. Second, capital mobility and labor mobility are perfect substitutes as growth-equalizing forces in the absence of international tax differences and of knowledge spillovers (or increasing returns). Third, tax-driven diversity in growth rates can be preserved under (i) the residence principle with either capital or labor mobility; or (ii) the source principle when labor is mobile; or (iii) when different countries adopt different international tax principles; or (iv) when different international tax principles are applied to capital incomes and labor incomes separately. [See Propositions 1-3.] Fourth, the relative growth effects of taxes between capital mobility and labor mobility are symmetric under the residence principle, but not also under the source principle [cf. Propositions 1 and 2] or when different countries follow different international tax principles [cf. footnotes 14 and 17]. Finally, income level convergence can be brought about by international transmission of technology through labor mobility in the presence of knowledge spillovers.

In sum, we have identified two major sources of disparity in income (and population) growth rates across countries. They are: (i) asymmetry in factor income tax rates, and (ii) asymmetry in international income tax principles, as adopted by different countries or applied to different factors of production. We have also shown how the growth effects of capital mobility and labor mobility can differ under these cases and how they are related to the relative bias in preferences towards quantity and quality of children. Although these differences can easily be eliminated if enough symmetry is assumed between the two factor inputs (e.g., uniform taxation of incomes from both factors), we believe that the asymmetries examined here are very real. In fact, the unequal barriers to the cross-border movements of the two factors can be another real source of asymmetry that is nonetheless ignored in our analysis.

The purpose of our paper has been to point out some relevant theoretical possibilities as solutions to the problem of economic development. We are not trying to claim that the sources of growth diversity and of asymmetry in the mobility of labor and capital we have analyzed here are necessarily the crux of the problem. They may be. But the answer has to be found from the data. In Razin and Yuen (1997a), we provide some evidence in support of the growth-equalizing effect of capital mobility and of the income-equalizing effect of labor mobility. In particular, our empirical results show that restrictions on labor flows tend to make per capita incomes more divergent across nations and/or regions.

On the theoretical front, some extensions are worthwhile. Since population changes in a country can be a result of both births/deaths and inflow/outflow of people, it is interesting to examine the link among fertility, migration, human capital formation, and income growth. Attention has to be drawn to the distinction between labor migration and labor mobility. (Here in this paper, we have been sloppy in using the two terms interchangeably as if they meant the same thing.) While the latter involves supplying effective labor to work in another country, the former also involves relocating one's home and changing one's national identity, hence the environment in which one raises children and invests in human capital. Cross-country wage rates will be equalized under labor mobility, but not necessarily under labor migration. What will be equalized instead under free migration are the lifetime utilities of the marginal migrant in the home and foreign countries. Consequently, it is not immediately obvious whether labor migration is a growth-equalizing force. Migration will also change the context in which questions of policy choice and national welfare should be addressed.

Throughout the paper, we have been concerned about possible explanations of international diversity in income levels and growth rates. As a mirror image of the "problem of economic development", one may sometimes want to know under what conditions (however stringent) the diversity may vanish completely. This is especially true for member countries of an economic union (such as countries in the European Union and federal states in the US). Our results suggest two essential preconditions: (i) harmonization of income tax rates, and (ii) labor mobility to facilitate knowledge spillovers. Condition (i) will ensure growth rate convergence irrespective of the international tax principle.[20] Condition (ii) will ensure income level convergence as well. These findings may not be surprising at all. We do hear them widely advocated by the EU.[21]

[20] One can conceive of some special cases under which a combination of asymmetric international tax principles and asymmetric income tax rates may produce symmetric growth rates. (See, e.g., the discussion in footnote 14.) But these are too special to be of general interest for our purpose.

[21] What is perhaps more surprising is that, in the presence of perfect labor mobility, capital mobility is neither necessary nor sufficient for both growth rate and level convergence.

The question is whether each national government will willingly choose to follow these guidelines.

In Razin and Yuen (1999), we show that, under capital mobility and with or without international tax coordination, it is optimal (both national-welfare-maximizing and global-welfare-maximizing) for each national government to eliminate taxes on capital incomes from all sources in the long run. Based on results obtained by Jones et al. (1997) for the optimal wage tax in a closed economy, we conjecture that the same will apply to labor income taxes under labor mobility in the absence of human capital externalities. In other words, optimal tax policies are growth-equalizing. But in these cases (absent knowledge spillovers), level convergence cannot be guaranteed.

In the presence of knowledge spillovers, however, the optimal structure of taxes on labor income will change. In particular, two kinds of inefficiencies associated with people's migration decisions and human capital investment decisions will arise. In terms of migration decisions, the importation of human-capital-poor workers from the low-wage country into the human-capital-rich (high-wage) country will impose a negative externality on the latter's workers by lowering their average level of human capital and consequently their wage profile. In the absence of immigration restrictions, the migrant workers will not take this negative external effect into account and thus over-migrate to the host country. In terms of education decisions, people in both the labor-importing and labor-exporting countries will under-invest in human capital. This is because each worker, being small, will ignore the positive external effect its human capital investment has in raising the average level of human capital in her/his workplace.

In Razin and Yuen (1997b), we show that inefficiency of the first kind can be corrected through a (non-resident) wage tax on imported workers plus a wage subsidy to domestic workers in the labor-importing country while inefficiency of the second kind can be eradicated through education subsidies in both the labor-importing and labor-exporting countries. In the non-cooperative equilibrium, the host country government will use the wage tax-subsidy package to limit labor mobility, thus generating a wage tax asymmetry and preventing the achievement of income equality. At the same time, the source-country government (who ignores the potential benefits of exporting more educated workers to the host country) will under-subsidize education, thus resulting in inefficiently low levels of income in both countries. In order to achieve income equality while internalizing the cross-country spillovers of human capital externalities, concerted efforts to lift barriers to labor mobility, to harmonize income tax rates, and to coordinate education (or human capital investment) policies are necessary. In other words, another plausible 'solution' to the "problem of economic development" lies in the lack of international policy cooperation. This speculative answer is again subject to empirical verification.

APPENDIX

Population Growth and Income Growth: A Closed Economy Example

Among the development patterns summarized by Romer (1989), the negative correlation between population growth rates and the levels of per capita income is classified as one stylised fact. Similar correlation that exists between population growth (g_N) and per capita income growth (g_y) is not as clear.[22] In fact, both of these correlations vary across development stages and tend to be negative during the more advanced stage of development.[23]

To understand the rationale behind the relation between population growth and income growth, let us consider a simple example that features their tradeoff as an equilibrium outcome in a closed economy. Imagine a dynastic family with N_t identical members in each period (t = 0,1,2,...) and two engines of growth (human capital and population). The typical agent cares about his own consumption c_t and the other family members N_t. His preferences are given by:

$$\underset{t=0}{\overset{4}{\varphi}} \exists^t N_t^{>} \left(\frac{c_t^{1-\Phi}}{1-\Phi} \right) \tag{A1}$$

[22] The dynamic evolution of this cross-sectional correlation is a question of *demographic transition*—a transition from high rates of fertility and mortality to relatively low rates during the development process—and thus varies with the phase of development of the various countries. See Ehrlich and Lui (1991) for a theory of demographic transition linking longevity, fertility, and economic growth.

[23] Since countries that exhibit low rates of growth of income will turn out to have low levels of income over time, these two types of correlation may not be all that distinguishable. They are, however, quite different from the more familiar negative relation between fertility and the level of income. The latter is explained by Becker and Lewis (1963) in terms of the tradeoff between the 'quantity' and 'quality' of children, where the rise in income raises the amount parents invest in their children, making each and every child a more 'expensive commodity' and thus causing a decline in the number of children.

where b is the subjective discount factor, x an altruism parameter, and s the inverse of the intertemporal elasticity of substitution in consumption. As long as $x > 0$, altruism is reflected not only in preference for 'quantity' but also 'quality' of children (viz., consumption per capita, or standard of living)—since, with positive x, there is weight given to quantity, but the weight on the consumption term is magnified as well. Observe that if $x > 1 - s$, then there will be a relative bias in preference towards quantity; whereas if $x < 1 - s$, the bias will be in the opposite direction.[24] When $x = 1 - s$, the representative agent is said to be 'fairly altruistic' in the sense that he cares only about the size of the total pie ($N_t c_t$) to be shared among all family members, but is indifferent to the exact sharing arrangement.

In each period *t*, there are N_t members in the representative family (given N_0 at $t = 0$). Each household member is endowed with one unit of time (net of the leisure and working time, assumed to be perfectly inelastic)[25] and possesses h_t of human capital and k_t of physical capital carried over from period $t - 1$ (given h_0 and k_0 at $t=0$) in each period *t*. S/he can split the unit time among learning in schools (e_t for education) and child-rearing (v_t for vitality). S/he also has to decide how much capital (k_{t+1}) to be carried forward to the ensuing period. Newly acquired effective labor ($N_t h_t$) and physical capital ($N_t k_t$) are supplied to the labor and capital markets in each period *t* at the prevailing competitive wage (w_t) and rental (r_t) rates.

The dynamics of the two growth engines are determined as follows. The child-rearing activity gives rise to population growth:

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[24] In terms of the utilitarian approach, the objective function (1) is a Millian (average utility) social welfare criterion when $x = 0$. When $x = 1$, it becomes a Benthamite (sum of utilities) criterion. See Razin and Yuen (1995) for details.

[25] Making leisure and worked hours endogenous will make the analysis less tractable. The allocation of time to work at home or abroad is allowed to change in the labor mobility framework considered in the text. We note here, though, that time allocation may vary over the stage of development in the economy. In poor countries, people may be more concerned about splitting time between work and child-rearing. In richer countries, the concern may be more about education *vis-à-vis* work and/or leisure.

$$N_{t+1} = D(v_t^{\alpha})N_t \tag{A2}$$

where D > 0 and $\alpha \in (0,1]$ are the fertility efficiency coefficient and productivity parameter respectively. One can think of N_{t+1} / N_t as one plus the number of children per family (when the number of parents is normalized to unity). Since the child-rearing cost (v) is increasing with the number of children, Dv^{α} can be thought of as the inverse function of this cost-quantity relation. The schooling activity contributes to human capital growth:

$$h_{t+1} = B\,(e_t^{\gamma})h_t \tag{A3}$$

where B > 0 is the knowledge efficiency coefficient and $\gamma \in (0,1]$ the productivity parameter.

Final output (Y_t) is produced by competitive firms using physical capital ($K_t = N_t\, k_t$) and total effective labor ($H_t = N_t\, h_t$) via a Cobb-Douglas-type technology: $Y_t = A\, K_t^{\varepsilon} H_t^{1-\varepsilon}$, where A > 0 is the production coefficient and $\varepsilon \in (0,1)$ the output share of capital. Goods produced are either consumed by the private sector ($N_t\, c_t$) and by the government (G_t) or invested in the form of physical capital (K_{t+1}). The societal resource constraint can thus be written as:

$$N_t c_t + G_t + K_{t+1} = Y_t = A K_t^{\varepsilon} H_t^{1-\varepsilon}\,. \tag{A4}$$

For simplicity, full depreciation is assumed for K_t, N_t, and h_t in each period.

The fiscal authority levies flat rate taxes on labor income (τ_{wt}) and capital income (τ_{rt}) to finance its spending (G_t), which is assumed to be a fraction (τ_t) of national output. Absent deficit finance, the fiscal budget is balanced in every period, with $\tau_t = \varepsilon\tau_{rt} + (1\text{-}\varepsilon)\tau_{wt}$. Below, we shall use Ω, Ω_w, and Ω_r to denote the tax wedges $1 - \tau$, $1 - \tau_w$, and $1 - \tau_r$ respectively.

Since, in a representative family, every member will receive equal treatment and the economy at large is closed to external loans, borrowing and lending at the individual level will be superfluous. Thus, the (effective) family budget constraint is $N_t\, c_t + K_{t+1} \leq \Omega_{wt}\, w_t N_t h_t + \Omega_{rt}\, r_t\, K_t$. The optimization problem facing the dynastic head is to choose $\{c_t , e_t , K_{t+1}, N_{t+1}, h_{t+1}\}_{t=0}^{¥}$ to maximize (A1) subject to (A2), (A3), and the budget constraint, given $\{w_t, r_t, \mathtt{W}_{wt}, \mathtt{W}_{rt}\}_{t=0}^{¥}$. The firm's problem is to choose the amount of capital (K^d_t) and effective labor (H^d_t) in each period t to maximize profit $Y_t - w_t H^d_t - r_t K^d_t$, given w_t and r_t. The equilibrium wage rates (w_t) and interest rates (r_t) are determined in the labor and capital markets under market clearing: $N_t h_t = H^d_t$ and $K_t = K^d_t$.

The set of first order conditions describing the optimizing behavior of the household and the firm and the market clearing conditions are as follows. The consumer's first order conditions (C) with respect to c_t, e_t, K_{t+1}, N_{t+1}, and h_{t+1} are given by:

$$N_t^{>-1} c_t^{-\Phi} = \mu_t, \tag{C1}$$

$$\mu_{h_t}(B e_t^{(-1} h_t = \mu_{N_t} \forall D(1-e_t)^{\forall-1} N_t, \tag{C2}$$

$$\mathtt{m}_t = \mathtt{bm}_{t+1}\, \mathtt{W}_{r_{t+1}}\, r_{t+1}, \tag{C3}$$

$$\mu_{N_t} = \exists\Big[\mu_{N_{t+1}} D(1-e_{t+1})^{\forall} + \mu_{t+1}(\Sigma_{w_{t+1}} w_{t+1} h_{t+1} - c_{t+1}) + + \left(\frac{>}{1-\Phi}\right) N_{t+1}^{>-1} c_{t+1}^{1-\Phi}\Big], \; and \tag{C4}$$

$$\mu_{h_t} = \exists(\mu_{h_{t+1}} B e_{t+1}^{(} \quad \mu_{t+1} \Sigma_{w_{t+1}} w_{t+1} N_{t+1}) . \tag{C}$$

The Lagrange multipliers (μ for "mu"ltipliers) at time t associated with the consumer budget constraint and the laws of motion of population and human capital are denoted by $\mathtt{m}_t$, $\mathtt{m}_{Nt}$, and $\mathtt{m}_{ht}$ respectively. The firm's first order conditions (F) are

$$w_t = (1-,)A\left(\frac{K_t}{H_t}\right)^{,}, \; and \tag{F1}$$

$$r_t = , A \left(\frac{K_t}{H_t}\right)^{, -1}. \tag{F2}$$

The equilibrium conditions in the labor and capital markets (E) are

$$N_t h_t = H_t^d, \ and \tag{E1}$$

$$K_t = K_t^d. \tag{E2}$$

Substituting (A2), (A3) and (F1) into (C2), we get,

$$\frac{(\ \mu_{h_t} h_{t+1}}{e_t} = \frac{\forall \mu_{N_t} N_{t+1}}{1-e_t}. \tag{A5}$$

Along the balanced growth path, time allocations and tax rates are constant, i.e., $e_t = e_{t+1}$, $W_t = W_{t+1}$, $W_{wt} = W_{wt+1}$, and $W_{rt} = W_{rt+1}$,so that (A5) implies that

$$\frac{\exists \mu_{h_{t+1}} h_{t+2}}{\mu_{h_t} h_{t+1}} = \frac{\exists \mu_{N_{t+1}} N_{t+2}}{\mu_{N_t} N_{t+1}}, \tag{A6}$$

where the two terms in (A6) are given respectively by

$$\frac{\exists \mu_{h_{t+1}} h_{t+2}}{\mu_{h_t} h_{t+1}} = 1 - (1-,)\Sigma_w \left(\frac{\exists \mu_{t+1} Y_{t+1}}{\mu_{h_t} h_{t+1}}\right) \tag{A7}$$

from (A2), (C4), and (F1), and

$$\frac{\exists \mu_{N_{t+1}} N_{t+2}}{\mu_{N_t} N_{t+1}} = 1 \ \left[(1-,)\Sigma_w + \left(\frac{>}{1-\Phi} - 1\right) (1-s)\Sigma \right] \left(\frac{\exists \mu_{t+1} Y_{t+1}}{\mu_{N_t} N_{t+1}}\right) \tag{A8}$$

from (A3), (C1), (C5), and (F1), with the savings rate (s) and the fiscal wedge (W) given by

$$s = \exists, \Sigma_r[D(1-e)^{\forall}]^{>}(Be^{(})^{1-\Phi} \quad and \quad \Sigma = , \Sigma_r + (1-,)\Sigma_w .$$

We shall restrict our attention here to the growth effects of taxes along the *balanced growth* path—the special path along which the time allocations as well as the rates of growth of population, human capital, physical capital, and output are all constant. Along this path, by combining (A5)—(A8), we can reduce the system of steady state equations to the following single equation in one single unknown, the time allocation (e).

$$\left(\frac{(}{\forall}\right)\left(\frac{1-e}{e}\right) = 1 + \left(\frac{>}{1-\Phi}-1\right)\left[\frac{(1-s)\Sigma}{(1-,)\Sigma_w}\right],$$

The growth rates can be expressed in terms of e as: $g_h = Be^{g} - 1$ and $g_N = D(1\text{-}e)^{a} - 1$, with $g_c = g_y = g_h$ and $g_K = g_Y$, where Y denotes total income and y per capita income (i.e., Y/N). Since $e+v = 1$, the competing use of time for the two growth activities implies a negative relation between g_y and g_N as found in the data. Note the dependence of the time allocations and the growth rates on the preference of the agent towards child quantity relative to quality (reflected by x/(1 - s)) and the effectiveness of time in producing quality relative to quantity (reflected by g/a). Assuming identical preferences (b, x, s) and technology (a, g, e, B,D), then growth rates can differ across isolated economies only if their governments adopt different fiscal policies (t, t_w, t_r).

To examine the growth effects of tax changes, two simple policy experiments can be considered. (i) Change in income taxes under uniform taxation of labor and capital incomes with compensating change in the output share of the government (i.e., t, t_w, t_r); and (ii) change in the capital income tax rate (t_r) compensated by a change in the labor income tax (t_w), keeping t constant. Comparative statics show that e, hence g_h, is decreasing (increasing) in t_r as x > (<) 1 - s under the first experiment, and the reverse is true under the second experiment. One can relate these effects to the tradeoff between the quantity and quality of children *a la* Becker and Lewis (1973). Other things equal, an increase in t_r will discourage investment in physical capital and encourage investment in child quantity if people are more altruistic ($x > 1 - s$) or investment in child quality if they are less so ($x < 1 - s$). As t_w increases, however, investment in both child quality and child quantity will be discouraged since the returns on both types of investment depend on the future stream of after-tax wage income. But the returns from investment in quantity depend also on the utility gain net of the cost of raising an additional child, which will be $\overset{3}{<}$ 0 as $x \overset{3}{<} 1- s$.[26] ‘Quantity’ investment will thus become more (less) favorable as x > (<) $1- s$ as a result of the tax increase. Piecing these arguments together confirms the result under experiment (i) when the increase in t_r is accompanied by an equal increase in t_w. But if the increase in t_r is accompanied by a reduction in t_w, the argument for t_w above will have to be reversed, with the t_w-effect dominating the t_r-effect, to obtain the result under experiment (ii).

[26] The utility gain from ‘quality’ investment net of the gain from ‘quantity’ investment is given by:

$$\mu_{ht} h_{t+1} - \mu_{Nt} N_{t+1} = \left(\frac{>}{1-\Phi} - 1 \right) \varphi \overset{4}{\underset{j=t+1}{}} \exists^{j-t} N_j^{>} c_j^{1-\Phi}.$$

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