NBER WORKING PAPER SERIES

CONVERGENCE IN GROWTH RATES: A QUANTITATIVE ASSESSMENT OF THE ROLE OF CAPITAL MOBILITY AND INTERNATIONAL TAXATION

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Working Paper No. 4336

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
April 1993

This paper was prepared for the Pinhas Sapir Conference on *Capital Mobility: New Perspectives*. For helpful discussions, we thank Willem Buiter, Isaac Ehrlich, Nouriel Roubini, T.N. Srinivasan, Oren Sussman, and Philippe Weil. The usual disclaimer applies. This paper is part of NBER's research program in Growth. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

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ABSTRACT

We provide an exploratory quantitative analysis of the role of capital mobility and international taxation in explaining the observed cross-country diversity in the long-run rates of growth of *per capita* and *total* incomes as well as the population growth rates. Corroborative evidence is found for the theoretical results on the convergence/divergence in long-term population, per capita and total income growth rates obtained in Razin and Yuen (1992). In particular, the data (and casual observations) show that (1) population growth and per capita income growth are negatively correlated across countries, (2) the total income growth rates are less variable than the per capita income growth rates across countries, and (3) asymmetry in capital income tax rates, coupled with the residence principle of international income taxation, can be an important source of cross-country differences in per capita income growth. Our computer simulations indicate that although the effects of liberalizing capital flows on long-run growth may not be all that sizable, the growth effects of changes in capital income tax rates can be tremendously bigger with than without capital mobility due to cross-border policy spillovers.

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I. Introduction

The objective of this paper is to provide a quantitative assessment of the role of two factors (often overlooked in the growth literature), viz., capital mobility and international taxation, in explaining the observed diversity in the long run rates of growth of *per capita* and *total* incomes as well as the population growth rates across countries. In so doing, we hope to shed some light on the *problem of economic development* posed by Lucas (1988), i.e., accounting for the observed diversity across countries.

The idea that government policy can induce *growth* effects and thus diversity in growth rates can be traced to asymmetry in tax policies has been explored quite extensively.[1] With a few exceptions, however, such analysis has been conducted for closed economies without taking account of the growing interaction among countries in the world in terms of commodity trade and capital flows. When capital is internationally mobile, the foreign-source capital income becomes an additional tax base from which the fiscal authorities in both the home and foreign countries can generate tax revenues. As we show in a companion paper [Razin and Yuen (1992)], the tax treatment of this income by the two governments and the degree of capital mobility will determine whether tax-driven growth differences can be preserved in an open economy. *Inter alia*, we find that:

(P1) under perfect capital mobility, long-term rates of growth of total (but not necessarily per capita) GDPs will be equal across countries; and

(P2) under asymmetric capital income tax rates, the *source* (or *territorial*) principle of international income taxation is growth-equalizing whereas the *residence* (or *worldwide*) principle is growth-diverging.

Here, we shall take these two propositions more seriously by confronting their empirical implications with data and/or observed facts and performing some exploratory quantitative analysis. To examine the allocative and growth effects of capital mobility and international taxation quantitatively, we shall also calibrate the open economy growth model in Razin and Yuen (1992) to the Group of Seven data over the period 1965-87 by splitting them into a 'two-country world': the US versus the other G6. Assuming that fundamental parameters remain the same across global tax and capital mobility regimes, we simulate the effects of various tax reforms and restrictions on capital flows on long-term resource allocation and growth rates.

The paper is organized as follows. Sections II and III explore the growth rates implications of capital mobility (P1) and international taxation of capital income (P2) respectively. The intuition behind (P1) and (P2) will also be reviewed. Section IV describes the parametric version of the Razin and Yuen (1992) model used in the calibration and simulation exercises, and reports the numerical results. Section V concludes.

II. The Role of Capital Mobility

Under free capital mobility, the law of diminishing returns implies that capital will move from capital-rich (low marginal product of capital, henceforth, MPK) countries to capital-poor (high MPK) countries.[2] Over time, such cross-border capital flows will equalize the MPKs prevailing in all countries.[3] Absent dynamic inefficiency in the sense of capital over-accumulation, the short run effect of such capital movement is to shorten the transition path of the capital-importing country and lengthen that of the capital-exporting country.[4] Without further restrictions, three situations are possible in the long-run:

(a) all capital in the world resides in one single country;
(b) no cross-border capital flows (i.e., back to autarky); and
(c) positive net capital flows from some countries to some other countries.

Both (a) and (b) are unrealistic cases; only (c) is empirically relevant. What, then, does it take to eliminate (a) and (b) even as theoretical possibilities? Case (a) will not occur if the MPK becomes infinitely high when the capital remaining in any capital-exporting country gets sufficiently small (i.e., the Inada conditions can rule out this corner solution). Case (b) will not occur as long as the countries are heterogeneous in some fundamentals. If they were homogeneous, capital flows would not have taken place in the first place. Since we also want to investigate the role of taxes on growth, let us assume that asymmetry in capital income tax rates is the factor that first induced cross-border capital flows. Suppose further that these countries were travelling along their steady state growth paths initially. Should these taxes remain different, the driving force that initiated capital movement to begin with will again be active when the countries return to their long-run autarky growth paths. As such, (b) can also be ruled out. The only interesting case that remains is therefore (c).

To understand how capital mobility may affect the convergence in long-term growth rates across countries, we have to be more specific about what we mean by the long-run. We shall follow the convention in the growth literature and identify *long-run growth* with *balanced* or *steady state growth*: the particular solution such that the rates of growth of all growing variables are constant (so that ratios among these variables defined in certain ways will also be time-invariant). Granted this definition, it is then not difficult to see that the stock of capital flowing from one country to another must be growing at the same rate as the total income in the former country as well as that in the latter for growth to be *balanced*. In other words, the balanced growth restriction forces the total income growth rates to be uniform across countries in the long-run, i.e., Proposition 1 of Razin and Yuen (1992).

Recall that per capita income equals total income divided by the size of the population. We can thus decompose the *total* income growth rates into the *per capita* income growth rates and *population* growth rates: $(1+g_Y) = (1+g_N)(1+g_y)$. Here, g_x denotes the growth rate of variable x between two periods, Y the total GDP, N the population, and y the per capita GDP (so $y = Y/N$). Together with (P1), this decomposition implies that $(1+g_N^A)(1+g_y^A) = (1+g_N^B)(1+g_y^B)$. Two empirical implications follow:

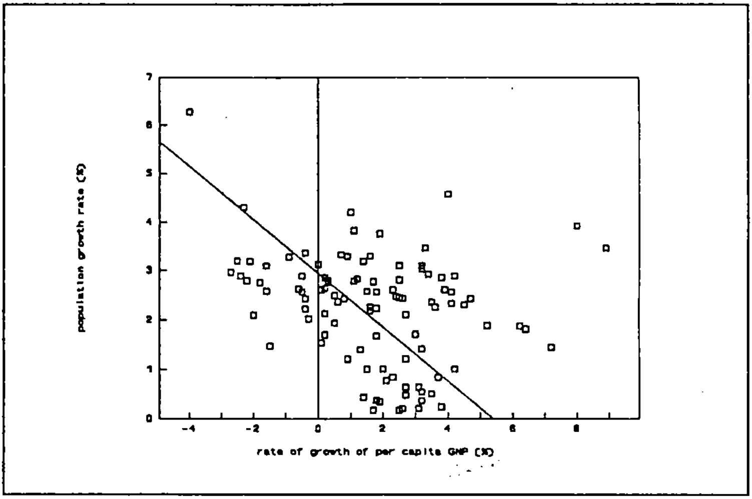
(1) *Long-term rates of growth of population and per capita incomes should be negatively correlated across countries*; and

(2) *Total income growth rates should exhibit less variation than per capita income growth rates across countries.*

Implication (1) says that countries with higher population growth rates will have, on average, slower growth in per capita income. While the negative correlation between population growth rates and the levels of per capita income has been fairly well accepted as a stylised fact,[5] similar correlation between population growth and per capita income growth is not as clear. The time series counterpart of these correlations is more a question of demographic transition—a transition from high fertility and mortality rates to low rates during the development process—and thus varies with the stage of development the countries are at.[6] Actually, both of these correlations tend to be negative during the more advanced phase of development. But since implication (1) refers to long-run average growth rates irrespective of whether the countries are DCs or LDCs, we show in Figure 1 below the correlation between g_N and g_y, incorporating countries at all stages of development. The downward sloping regression line fitted through the points 'roughly' confirms the negative correlation.[7] As a further confirmation, we find that the correlation coefficient between g_N and g_y is -0.27.

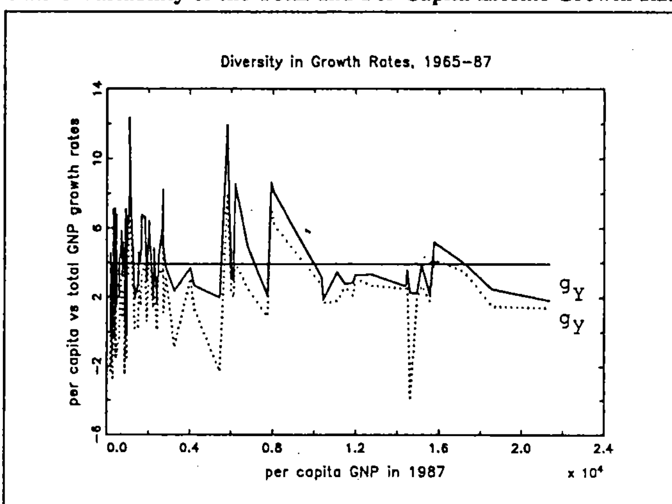
Implication (2) does not follow directly from, and is actually a weaker form of, (P1). It takes account of the fact that, in the real world, countries—being bombarded by all kinds of shocks from time to time—will not be operating on their steady state growth paths most of the time. Given such short-term disturbances, we should not expect to find support for the strong version of (P1) as stated above. However, if we average the growth rates in every country over longer time periods, these fluctuations will be smoothed out so they will be

Figure 1
Correlation between Population Growth and Per Capita Income Growth



Source: 1965-87 data for the 120 countries (excluding those with missing data) listed in Tables 1 and 26 of the 1989 World Development Report.

Figure 2
Relative Variability of the Total and Per Capita Income Growth Rates



Source: same as Figure 1.

closer to being in the long-run. Then, the weak version of (P2) says that the average total income growth rates should be less variable than the average per capita income growth rates.

Figure 2 plots these two income growth rates for the various countries (averaged over the period 1965-87) against their per capita income levels in 1987. The horizontal straight line (at a GNP growth rate of 3.94%) portrays the ideal situation where (P1) holds exactly. Simple eye-ball observation seems to indicate that there is less variability in the total GNP growth rates across countries than their per capita counterpart. To check our eyesight, we compute the coefficients of variation (CVs) in these two growth rates from the data described in Figures 1 and 2, and find that the CV in the total income growth rates [= 0.58 for $g_Y \equiv \ln((1+g_N)(1+g_y))$, and 1.28 for $g_Y \equiv (1+g_N)(1+g_y)-1$] indeed falls short of the CV in the per capita income growth rates [= 1.35]. Therefore, implication (2) is supported by the data.

With capital market imperfections in the real world, it is not surprising to find that the data only provide a 'rough' confirmation of implications (1) and (2), hence (P1). Since perfect capital mobility is a precondition for (P1), we should expect these implications to find stronger support from a sample of countries with less restrictions on capital flows. This hypothesis is, nonetheless, difficult to test due to the data problem: data such as "Restrictions on Payments on Capital Transactions" by the IMF that one may want to use as proxies for capital controls do not take into account the degrees of intensity of such restrictions.

III. The Role of International Taxation

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 (i) the after-tax rates of return on capital ($\bar{r}$) and, indirectly, (ii) the rates of growth of per capita consumption and population (g_c and g_N) across countries.

The relation between (i) and (ii) can be obtained from the familiar marginal condition for the intertemporal choice of consumption adjusted for capital taxes: $IMRS_{t-1,t} = 1+\bar{r}_t$ where $IMRS_{t-1,t}$ is the intertemporal marginal rate of substitution between consumption in period t−1 and consumption in period t. If preferences are isoelastic in consumption and people are altruistic towards each other, we can rewrite the condition as: $(1+g_{ct})^{\sigma}(1+g_{Nt})^{1-\xi} = \beta(1+\bar{r}_t)$, where σ (> 0) is the reciprocal of the intertemporal elasticity of substitution in consumption, ξ (≤ 1) the degree of interpersonal altruism, and β the subjective discount factor. Focusing on the balanced growth path where growth rates are constant, (per capita) consumption and output grow at the same rate, and (P1) holds, and taking the ratio of growth rates in two countries (A and B) after some rearrangement, we get:

$$\frac{1+\bar{r}^A}{1+\bar{r}^B} = \begin{cases} \left(\dfrac{1+g_y^A}{1+g_y^B}\right)^{\xi-(1-\sigma)} & \text{if } \xi \neq 1-\sigma \\ \dfrac{1+g_Y^A}{1+g_Y^B} & \text{if } \xi = 1-\sigma \end{cases}$$

Without spelling out the details, we simply note here that $\xi = 1-\sigma$ is a special case where people are completely altruistic towards each other (i.e., treat each other as equal). Therefore, the object of interest in this case is total income growth g_Y^i. When $\xi \neq 1-\sigma$, per capita income growth g_y^i becomes relevant.

The above formula shows how capital income taxes can affect the relative income growth rates via the after-tax rates of return on capital ($\bar{r}$'s). At this point, the reader may be tempted to think that no-arbitrage restrictions will force the $\bar{r}$'s to be equalized across countries under perfect capital mobility, implying convergence in both the per capita and total income growth rates. In fact, this reasoning is true only under the *source* or *territorial* tax principle, whereby all types of income originating in the country are taxed uniformly regardless of the place of residence of the income recipients. Under the alternative *residence* or *worldwide* principle, residents are taxed on their worldwide income uniformly regardless of the source of income, while nonresidents are not taxed on income originating in the country. In that case, domestic-source and foreign-source incomes receive identical tax treatment for residents within each country, but asymmetric treatment across countries if different countries impose different capital income tax rates. Asymmetry in $\bar{\tau}$'s implies, in turn, asymmetry in growth rates.[8]

The formula also indicates that under residence-based taxation, when $\xi \neq 1-\sigma$, asymmetric tax rates may have differential effects on the growth of per capita income and population. In particular, when people are more individualistic or selfish ($\xi < 1-\sigma$), the country with a higher capital tax rate will exhibit faster growth in per capita income and slower growth in population. The reverse is true when people are more altruistic towards each other ($\xi > 1-\sigma$). Although the link is not that direct, one can relate this discussion to the trade-off between the quantity and quality of children a la Becker and Lewis (1973). $\xi > 1-\sigma$ then corresponds to the case where people care more about quantity than quality. Hence, the population growth rate is higher, but per capita income growth lower, when capital taxes are relatively high (so investment in physical capital becomes less attractive relative to investment in either the quality or quantity of children), and vice versa.

Everything seems to be possible under (P2). In order to determine whether growth rates will more likely be converging or diverging in the face of differential capital tax rates, we display below a table extracted from Table 2.1 of Frenkel, Razin and Sadka (1991) to see which international income tax principle is more popular (at the individual and corporate levels) among major industrial countries. 'R' in the table stands for the residence principle, and 'S' for the source principle.

Table 1 Taxation of Foreign-Source Capital Income—Selected Countries

	Individual		Corporate	
Country	Top tax rate (%)	Dominant principle	Top tax rate (%)	Dominant principle
Belgium	55	R	43	S
Denmark	68	R	50	R (with credit)
France	53	R	39	S
Germany	56	R	56	R (with deduction)[a]
Greece	50	R	35	R (with credit)
Ireland	58	R	43	R (with credit or deduction)
Italy	50	R	46	R (with credit)[b]
Luxembourg	56	R	36	R (with credit)
Netherlands	72	R	36	R (with credit or deduction)[a]
Portugal	40	R	36	R (with credit)
Spain	56	R	35	R (with credit)
United Kingdom	60	R	35	R (with credit)
Canada	42-49[c]		38	
Japan	50		42	
United States	28-38[d]	R	34	R (with credit)

Sources: Lans Bovenberg and George Kopits, "Harmonization of Taxes on Capital Income and Commodities in the European Community," IMF, October 1989, and *Individual Taxes: A Worldwide Summary*, Price Waterhouse, 1989.
[a] The source principle applies under treaties and for substantial participation in foreign companies.
[b] With refund for excess foreign tax credit.
[c] Including provincial taxes.
[d] Including state taxes.

Evidently, the residence principle is the dominant tax principle among countries in the world. The production efficiency, Ramsey (second best) efficiency, and capital export neutrality implications of residence-based taxation may explain its popularity.[9] From (P2), we can thus conclude that asymmetry in cross-country capital taxes is a plausible explanation of diversity in growth rates. A closer examination of the relation between capital taxes on the one hand and income and population growth rates on the other suggests that $\xi > 1-\sigma$ seems to conform 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. This phenomenon is also revealed by the calibration result below.

IV. The Parametric Model: Calibration and Simulations

In this section, we shall briefly review the analytical framework in Razin and Yuen (1992), parameterize and calibrate the model to real world data, and simulate the effects of different tax structures and restrictions on capital flows on long-term growth rates across countries.

We consider a two-country dynastic world with N_t^i identical, rational agents in each country i in each period t (i = A,B; t = 0,1,2,...), with two engines of growth (human capital and population) and capital mobility, with frictionless and competitive markets, and without international policy coordination. The typical agent cares about his own consumption c_t^i and the population in his country N_t^i. His preferences are given by:

$$\sum_{t=0}^{\infty} \beta^t (N_t^i)^{\xi} \left[\frac{(c_t^i)^{1-\sigma}}{1-\sigma} \right].$$

where β is the subjective discount factor, ξ the degree of altruism towards people, and σ the inverse of the intertemporal elasticity of substitution in consumption.

Each household member is endowed with one unit of time, possesses h_t^i of human capital and S_t^i/N_t^i of physical capital carried over from period t−1 (given S_0^i/N_0^i at t=0), and receives a lump-sum transfer of T_t^i/N_t^i from its government, in each period t. He/she can split the unit time among work (n_t^i), learning in schools (e_t^i), and child-rearing (v_t^i), and allocate the physical capital as inputs to final goods production ($\eta_t^i S_t^{ii}/N_t^i$) and human capital formation ($k_{ht}^i = (1-\eta_t^i)S_t^{ii}/N_t^i$). He/she also has to decide how much capital (S_{t+1}^i) to be carried forward to the ensuing period, and where to locate such investment—at home (S_{t+1}^{ii}) or abroad (S_{t+1}^{ij}).

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

$$N_{t+1}^i = D(v_t^i)^\alpha N_t^i + (1-\delta_N)N_t^i$$

where D and α are the fertility efficiency coefficient and productivity parameter respectively, and δ_N is the mortality rate. The schooling activity contributes to human capital growth:

$$h_{t+1}^i = B(k_{ht}^i)^\gamma (e_t^i h_t^i)^{1-\gamma} + (1-\delta_h)h_t^i$$

where B is the knowledge production coefficient, γ the share of the physical capital input, and δ_h the rate of depreciation of human capital.

Each national government levies five kinds of distortionary taxes—on domestic consumption (τ_{ct}^i),[10] on domestic labour income (τ_{wt}^i), on residents's domestic-source capital income (τ_{rDt}^i), on residents's foreign-source capital income net of taxes paid to the foreign government (τ_{rFt}^i), and on capital income earned by non-residents in its country (τ_{rNt}^i)—to finance its exogenous spending G_t^i and transfers T_t^i. Depreciation allowances are deductible from capital taxes. Without deficit finance, the fiscal budget is balanced in every period.

Final output is produced with physical capital (K_{yt}^i)—supplied domestically ($\eta_t^i S_t^{ii}/N_t^i$) and, if there exists capital inflow, imported from abroad (S_t^{ji})—and total effective labour ($H_t^i = N_t^i n_t^i h_t^i$) via a Cobb-Douglas technology. Accordingly, gross domestic product is given by:

$$Y_t^i = A(K_{yt}^i)^\epsilon (H_t^i)^{1-\epsilon}$$

where A is the production coefficient, and ϵ the output share of capital. Since total resources can be spent on private and government consumption and investment, the resource constraint in country i can be stated as:

$$N_t^i c_t^i + S_{t+1}^i - (1-\delta_k)S_t^i + G_t^i = GNP_t^i$$

where GNP_t^i is the sum of Y_t^i and the net capital income from abroad, $[(1-\tau_{rNt}^j)(r_t^j-\delta_k)+\delta_k]S_t^{ij} - [(1-\tau_{rNt}^i)(r_t^i-\delta_k)\delta_k]S_t^{ji}$, and r_t^i is the rate of return on, and δ_k the rate of depreciation of, physical capital.

We lay out in the appendix the set of equations that describes the global steady state growth equilibrium. These equations are used to calibrate and simulate the model along the lines of Lucas (1990a). Imagine that the US and the G6 were growing along their balanced growth paths in the period 1965-87, we choose benchmark values for the parameters $(\beta,\sigma,\xi,\alpha,\varepsilon,\gamma,\delta_k,\delta_h,\delta_N,A,B,D)$, allocations $(c^i,n^i,e^i,\eta^i,S^{ii},S^{ij}, N^Bh^B/N^Ah^A)$, growth rates (g_h^i,g_N^i), and policy variables $(g^i,T^i,\tau_c^i,\tau_w^i,\tau_{rD}^i,\tau_{rF}^i,\tau_{rN}^i)$ so that the theoretical equilibrium values of these variables 'match' as closely as possible their long-run average values from the data. Long-run levels and growth rates data are drawn largely from the 1989 World Development Report, and tax rates data from Mendoza, Razin and Tesar (1992). Some of the parameter values are borrowed from previous empirical studies. Others whose values are less well-documented, together with some of the variables which do not have direct empirical counterparts, are treated as unknowns and 'estimated' from the steady state equations. In our benchmark case, we assume perfect capital mobility and the international income tax principle is residence-based (given most of the G7 countries follow the residence principle). Below, we summarize the benchmark parameter and initial values.

Table 2. Summary of Benchmark Values

Initial steady state values		
Per capita output in the US	y^A	1.000 (1.000)
Per capita output in the G6	y^B	1.050 (0.725)
Consumption-output ratio in the US	C^A/Y^A	0.650 (0.660)
Consumption-output ratio in the G6	C^B/Y^B	0.660 (0.588)
Capital-output ratio in the US	K^A/Y^A	1.795
Capital-output ratio in the G6	K^B/Y^B	1.751
Ratio of net capital flow from the G6 to the US (= US's current account deficits) to US output	S^{AB}/Y^A	-0.035 (-.035)
Fraction of capital allocated to goods production in the US	η^A	0.690
Fraction of capital allocated to goods production in the G6	η^B	0.714
Fraction of time allocated to goods production in the US	n^A	0.409
Fraction of time allocated to goods production in the G6	n^B	0.430

Fraction of time allocated to human capital formation in the US	e^A	0.376
Fraction of time allocated to human capital formation in the G6	e^B	0.401
Population growth rate in the US	g_N^A	0.013 (0.010)
Population growth rate in the G6	g_N^B	0.008 (0.006)
Per capita income growth rate in the US	g_y^A	0.018 (0.015)
Per capita income growth rate in the G6	g_y^B	0.023 (0.028)
Initial values of policy variables		
Output share of government spending in the US	G^A/Y^A	0.200 (0.210)
Output share of government spending in the G6	G^B/Y^B	0.200 (0.176)
Ratio of lump-sum transfers to output in the US	T^A/Y^A	0.243
Ratio of lump-sum transfers to output in the G6	T^B/Y^B	0.168
Consumption tax rate in the US	τ_c^A	0.320 (0.050)
Consumption tax rate in the G6	τ_c^B	0.130 (0.014)
Labour income tax rate in the US	τ_w^A	0.240 (0.240)
Labour income tax rate in the G6	τ_w^B	0.303 (0.300)
Tax rate on domestic-source capital income of the US residents	τ_{rD}^A	0.300 (0.300)
Tax rate on domestic-source capital income of the G6 residents	τ_{rD}^B	0.290 (0.290)
Tax rate on foreign-source capital income of the US residents	τ_{rF}^A	0.300 (0.300)
Tax rate on foreign-source capital income of the G6 residents	τ_{rF}^B	0.290 (0.290)
US tax rate on G6 residents' capital income earned in the US	τ_{rN}^A	0.000 (0.000)
G6 tax rate on US residents' capital income earned in the G6	τ_{rN}^B	0.000 (0.000)
Production parameter values		
Capital's share in goods production	ε	0.250
Capital's share in human capital production	γ	0.165
Fertility productivity parameter	α	1.000
Rate of depreciation of physical capital	δ_k	0.050
Rate of depreciation of human capital	δ_h	0.080
Mortality rate	δ_N	0.009
Output production coefficient	A	1.848
Human capital production coefficient	B	0.245
Fertility coefficient	D	0.104
Preference parameter values		
Subjective discount factor	β	0.912
Inverse of intertemporal elasticity of substitution	σ	0.398
Altruism parameter	ξ	0.956

N.B. Numbers in brackets are actual long-run average (1965–87) data for the G7, whereas all other numbers are calibrated to match closely the data while satisfying all the steady state equations.

We skip the details about our choice of parameter and initial values because we have achieved only partial success in calibrating our model to data after prolonged experimentation. As is evident from comparing the numbers in Table 2 with actual data, there is at least three aspects of the data that our model values fail to mimic: (a) the per capita income should be lower in the G6 than in the US, (b) the output shares of both private and public consumption should be lower in the G6 than in the US, and (c) the consumption tax rate should be much higher in the G6 than in the US.[11] The reason for these discrepancies is obvious: Capital movement between the US and the G6 is not 100% free. In what follows, the reader is welcomed, if he/she so wishes, to interpret what we label as the US and G6 simply as two artificial economies. The hypothetical experiments described below will then serve as an illustration of the potential quantitative effects of capital mobility and tax changes in an artificial (but hopefully close enough to real) environment.

Our first experiment examines the role of capital mobility. It involves switching from a state where cross-country capital flows are perfectly mobile to a state where capital movements are shut down altogether. The autarky equilibria are computed for the two countries separately under the same parameter and policy settings as in the free mobility case, assuming that lump-sum taxes or subsidies are used to rebalance the fiscal budgets in the absence of foreign-source capital income tax proceeds.

The effects of capital control on growth rate and MPK differentials are intuitively clear. As the numbers on the first rows of the four panels in Table 3 indicate, shutting down capital mobility leads to bigger diversity in cross-country growth rates and rates of return on physical capital. Without capital flows, the pre-tax returns r's, which are equalized under capital mobility and the residence principle, are now different across countries ($\Delta r > 0$), let alone the post-tax returns τ's. Not surprisingly, the diversity in both the population and per capita income growth rates widens. The population growth rate rises from 1.30% to 1.37% in the US, and falls from .83% to .79% in the G6, leading to an increase in the population growth rate differential from .47% to .58%. On the other hand, the per capita income growth rate drops from 1.80% to 1.66% in the US, and rises from 2.28% to 2.35% in the G6. The per capital income growth differential therefore grows from .48% to .69%. Under capital controls, (P1) need not hold. The total income growth rates diverge from the uniform rate of 3.12% under capital mobility to 3.05% in the US and 3.16% in the G6. Losing the opportunity to channel savings abroad, the G6 devotes them back to domestic production, causing a rise in both the long-run level and rate of growth of per capita GDP. The reverse is true in the US, the capital-importing country before the imposition of capital controls. The steady state welfare levels under the two capital mobility regimes, hence the welfare loss from shutting down capital flows, depend on the steady state levels of the normalizing variables (stocks of human capital in the two countries), which cannot be determined uniquely in models of endogenous growth such as ours without tracing out the transitional dynamics. Without carrying out this exercise, we can nonetheless be sure that such capital restrictions will give rise to welfare losses for both countries simply by observing that autarky is feasible but not chosen by agents in the two countries under the global free capital mobility equilibrium.

The second experiment demonstrates the effects of changes in the capital income taxes. By capital income tax reform, we mean altering the tax rate on capital income with compensating changes in lump-sum taxes to balance the fiscal budgets. We continue to assume the residence principle under capital mobility so that τ_r^i (i = A,B) in the first two panels of Table 3 refers to both τ_{rD}^i and τ_{rF}^i (with $\tau_{rN}^i = 0$). Only very small tax changes are considered in the perfect-capital-mobility (PCM) case because, given the complexity and nonlinearity of the equations, the GAUSS equation solver we use for our simulations breaks down easily for larger deviations from the initial steady state. Relatively bigger tax changes are considered, however, in the no-capital-mobility (NCM) case for two reasons.

Table 3. Capital Income Tax Reforms with and without Capital Mobility

Perfect Capital Mobility: (a) Reform in the US

g_N^A	g_N^B	Δg_N	g_y^A	g_y^B	Δg_y	g_Y^A	g_Y^B	Δg_Y	Δr	$\Delta \bar{T}$	τ_r^A
1.300	.830	-.470	1.800	2.275	.475	3.123	3.123	.000	.000	.1820	30.000
1.305	.835	-.469	1.791	2.265	.474	3.119	3.119	.000	.000	.1818	29.999
1.309	.840	-.469	1.781	2.255	.473	3.114	3.114	.000	.000	.1816	29.998
1.314	.845	-.468	1.772	2.245	.473	3.109	3.109	.000	.000	.1814	29.997
1.318	.850	-.468	1.762	2.235	.472	3.104	3.104	.000	.000	.1812	29.996

Perfect Capital Mobility: (b) Reform in the G6

g_N^A	g_N^B	Δg_N	g_y^A	g_y^B	Δg_y	g_Y^A	g_Y^B	Δg_Y	Δr	$\Delta \bar{T}$	τ_r^B
1.300	0.830	-.470	1.800	2.275	.475	3.123	3.123	.000	.000	.1820	28.786
1.294	0.823	-.471	1.813	2.288	.475	3.130	3.130	.000	.000	.1823	28.785
1.289	0.818	-.471	1.822	2.298	.476	3.135	3.135	.000	.000	.1826	28.784
1.285	0.813	-.472	1.831	2.308	.477	3.140	3.140	.000	.000	.1828	28.783
1.289	0.817	-.471	1.823	2.299	.476	3.136	3.136	.000	.000	.1829	28.782

No Capital Mobility: (a) Reform in the US

g_N^A	g_N^B	Δg_N	g_y^A	g_y^B	Δg_y	g_Y^A	g_Y^B	Δg_Y	Δr	$\Delta \bar{T}$	τ_r^A
1.370	0.793	-.577	1.655	2.348	0.693	3.048	3.159	.111	.127	.271	30.000
1.353	0.793	-.560	1.696	2.348	0.652	3.072	3.159	.087	.313	.254	29.000
1.335	0.793	-.542	1.737	2.348	0.611	3.096	3.159	.063	.494	.237	28.000
1.317	0.793	-.524	1.778	2.348	0.570	3.119	3.159	.040	.670	.221	27.000
1.300	0.793	-.507	1.818	2.348	0.530	3.142	3.159	.017	.842	.204	26.000

No Capital Mobility: (b) Reform in the G6

g_N^A	g_N^B	Δg_N	g_y^A	g_y^B	Δg_y	g_Y^A	g_Y^B	Δg_Y	Δr	$\Delta \bar{T}$	τ_r^B
1.370	0.793	-.577	1.655	2.348	0.693	3.048	3.159	0.111	.127	.271	28.786
1.370	0.779	-.591	1.655	2.379	0.724	3.048	3.177	0.129	-.020	.284	28.000
1.370	0.761	-.609	1.655	2.419	0.764	3.048	3.198	0.150	-.202	.300	27.000
1.370	0.743	-.627	1.655	2.458	0.803	3.048	3.220	0.172	-.379	.316	26.000
1.370	0.726	-.644	1.655	2.497	0.842	3.048	3.241	0.193	-.552	.332	25.000

N.B. (i) All entries in the table are in percentage terms (i.e., multiplied by 100);
(ii) $\Delta x \equiv x^B - x^A$ for variable x.

Computationally, the lower dimensionality of the autarky equilibrium allows us to examine bigger changes. Besides, the growth rate changes resulting from a change in the capital tax of the same order of magnitude as in the PCM case are negligible, almost totally unnoticeable. This suggests that the *growth* effects of capital taxes are much bigger with than without capital mobility: .004 of a one percent change in τ_r under PCM approximates the growth effect of a one percent change in τ_r under NCM. Note also that there exists cross-country spillovers of growth effects under PCM, but tax changes in one country will have no effect on the growth rates in the other country under NCM. Without opening the economy, the recent growth literature may thus have substantially under-estimated the potentially large growth effects due to tax changes and cross-border policy spillovers.

A few remarks on the implications of capital tax reforms in the two countries for population and income growth and the diversity in these growth rates are in order.

(1) The effects of lowering capital taxes on the growth of population, per capita and total incomes are asymmetric and non-monotonic in the US (the high-τ_r country) and the G6 (the low-τ_r country) under PCM, but symmetric and monotonic under NCM. In the PCM case, while a reduction in τ_r^A may stimulate an increase in g_N^A and a fall in g_y^A and g_Y^A initially, these changes can be reversed for further tax reduction. Opposite changes in g_N^B, g_y^B, and g_Y^B occur in response to a fall in τ_r^B. In the NCM case, g_N will fall and g_y and g_Y rise following a decrease in τ_r. These seemingly weird results can be understood in terms of the response of $\bar{r}$ to changes in τ_r. Recall that $\bar{r} = (1-\tau_r)(MPK-\delta_k)$. Since $1-\tau_r$ rises and MPK falls—due to the stimulative effect of tax reduction on capital accumulation and diminishing marginal productivity—when τ_r is lowered, the effect on $\bar{r}$ is unclear in general. This is reminiscent of the Laffer Curve, which can be multi-modal in our setup. The differential effects of tax rate changes on the growth of population (g_N) and per capita income (g_y) are a consequence

of our benchmark parameter restriction, viz., $\xi > 1-\sigma$.

(2) There is positive co-movement of the various growth rates in the US and G6 under PCM. This is because both countries are exposed to the same (physical capital) investment opportunities under capital mobility and the residence principle. In the absence of policy spillovers, no such co-movement exists in the NCM case.

(3) The growth rate differentials Δg_N, Δg_y and Δg_Y may not necessarily be narrowed as the capital tax rates in the two countries get closer. This is not a violation of (P2) because (P2) only predicts the signs, but not also the sizes, of these gaps. In fact, these growth rate gaps will not be closed even if the two countries have identical capital tax rates because what really matter are the after-tax rates of return on capital $\bar{r}$'s (not the tax rates themselves), and these $\bar{r}$'s will not be equalized because the consumption and labour income taxes are different across countries.

In yet another experiment (not shown), we switch the international income tax rule from the residence principle to the source principle. The theoretical results in Razin and Yuen (1992) are confirmed numerically. In particular, the population, per capita and total income growth rates are symmetric across countries despite capital tax asymmetries. So are the post-tax returns $\bar{r}$'s, implying efficiency in the allocation of world savings. The Ramsey (and production) inefficiency of the source principle, however, results in welfare losses relative to the residence principle.

V. Conclusion

In this paper, we have found some supportive evidence for the theoretical results on the convergence in long-term population, per capita and total income growth rates under capital mobility and global taxation obtained in Razin and Yuen (1992). In particular, we find that (1) population growth and per capita income growth are negatively correlated across countries, (2) the total income growth rates are less variable than the per capita income growth rates across countries, and (3) asymmetry in capital income tax rates, coupled with the residence principle, can be an important source of cross-country differences in per capita income growth. Computer simulations are run to assess the quantitative effects of varying the degree of capital mobility and the rates of capital income taxes. Our numerical results show that although the effect of liberalizing capital flows on long-run growth may not be all that sizable, the growth effects of tax changes can be tremendously magnified by cross-border capital flows and policy spillovers.

Having stated the good news, let us also caution the reader by admitting that our analysis is preliminary—largely exploratory in nature—and incomplete. We have not been successful in matching all relevant aspects of our model to real world data. Incorporating some forms of capital controls into the theoretical framework may help. Econometric estimation of the unknown parameters can reduce the degree of arbitrariness that calibration entails. If one's purpose of conducting such experiments is to better understand the effects of various factors affecting growth and development, one may also want to expand the sample and consider perhaps the LDCs versus the DCs (less similar economies) rather than the US versus the G6 (more similar economies). Regarding the policy experiments, other kinds of changes such as the consumption tax reform, labour income tax reform, population control, with and without international policy coordination are of interest. It will also be important to compute the transitional dynamics for the evaluation of policy effects in both the short-run and long-run and for welfare calculations. We hope our work serves as a fruitful first step for more serious research in the area of growth and policy in open economies.

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Endnotes

1. See, e.g., Rebelo (1991) and Jones and Manuelli (1990) for a qualitative analysis, and King and Rebelo (1990), Lucas (1990) and Kim (1991) for a quantitative assessment, of the *level* and *growth* effects of various tax structures.

2. See Lucas (1990b) for why, in practice, we may not see huge flows of capital from rich to poor countries.

3. Post-tax MPKs if taxes are levied on capital incomes (domestic or foreign). Note, however, that equalization of after-tax MPKs through capital movement will, in general, not obtain under the *residence* principle. See Section III below.

4. Barro, Mankiw, and Sala-i-Martin (1992) addresses exactly this issue, i.e., how capital mobility affects the speed of converging from the transition path to the steady state growth path.

5. This negative correlation is referred to by Romer (1989) as stylised fact 9 in his survey paper.

6. See Ehrlich and Lui (1991) for a theory of the demographic transition linking longevity, fertility, and economic growth.

7. Had we plotted $1+g_N^i$ against $1+g_y^i$ instead, these points should line up along a rectangular hyperbola if implication (1) holds.

8. Note from the lower half of the formula, though, that existence of balanced growth requires symmetry in τ's, hence the capital income tax rates, under the residence principle if $\xi = 1-\sigma$ (since the right hand side equals unity by (P1)).

9. See Frenkel, Razin and Sadka (1991) or Razin and Yuen (1992) for a discussion of these implications of the residence principle.

10. The consumption taxes were absent in Razin and Yuen (1992). We incorporate them here because the US and the G6 differ prominently in their VAT (value-added tax) rates. Taking account of these taxes can help us better calibrate our model.

11. The output shares of capital and transfer payments may not match the data very well either. The reported K/Y and T/Y numbers in Table 2 are chosen to satisfy the resource and government budget constraints respectively.

APPENDIX: Steady State Growth Equilibrium

Since we want to analyze the long-run effects of changes in taxes and capital mobility, we shall focus only on steady state behavior. Along the balanced growth path, the time allocations (n,e,v), capital sector-allocation factor η^i, tax rates $(\tau_c^i, \tau_w^i, \tau_{rD}^i, \tau_{rF}^i, \tau_{rN}^i)$ and growth rates (g_h^i, g_N^i) are constant. The following 'ratio' variables will also be time-invariant:

$$c^i = \frac{c_t^i}{h_t^i},\ S^{ii} = \frac{S_t^{ii}}{N_t^i h_t^i},\ S^{ij} = \frac{S_t^{ij}}{N_t^i h_t^i},\ k_y^i = \frac{K_{yt}^i}{N_t^i h_t^i},\ k_h^i = \frac{k_{ht}^i}{h_t^i},\ G^i = \frac{G_t^i}{N_t^i h_t^i},\ T^i = \frac{T_t^i}{N_t^i h_t^i},\ y^i = \frac{y_t^i}{N_t^i h_t^i}.$$

We can then obtain the following equations as steady state analogues of equations (7)–(10), (2), (3), (4)', and (5) in Razin and Yuen (1992).

$$\frac{(1-\tau_w^i)(1-\epsilon)y^i/n^i}{(1-\tau_{rD}^i)\epsilon y^i/k_y^i+\delta_k} = \left(\frac{1-\gamma}{\gamma}\right)\left(\frac{k_h^i}{e^i}\right),$$

$$\frac{n^i}{e^i} = \frac{1-\beta^i(1-\gamma R_h^i)}{\beta^i(1-\gamma)R_h^i},$$

$$\beta^i(1+\tau_c^i)c^i\left(\frac{\xi}{1-\sigma}-1\right)\left(\frac{\alpha R_N^i}{1-n^i-e^i}\right) = (1-\tau_w^i)(1-\epsilon)\left(\frac{y^i}{n^i}\right)\left\{1-\beta^i\left[1+\frac{\alpha R_N^i[(1-\gamma)n^i-\gamma e^i]}{(1-\gamma)(1-n^i-e^i)}\right]\right\},$$

$$(1-\tau_{rD}^i)\left(\frac{\epsilon y^i}{k_y^i}-\delta_k\right) = \frac{(1+g_N^i)(1+g_h^i)}{\beta^i}-1 = (1-\tau_{rF}^i)(1-\tau_{rN}^j)\left(\frac{\epsilon y^j}{k_y^j}-\delta_k\right),$$

$$g_h^i = B(k_h^i)^\gamma(e^i)^{1-\gamma}-\delta_h,$$

$$g_N^i = D(N^i)^\alpha-\delta_N,$$

$$c^i + [(1+g_N^i)(1+g_h^i)-(1-\delta_k)]S^i + G^i$$
$$= y^i + \left[(1-\tau_{rN}^j)\left(\frac{\epsilon y^j}{k_y^j}-\delta_k\right)+\delta_k\right]S^{ij} - \left[(1-\tau_{rN}^i)\left(\frac{\epsilon y^i}{k_y^i}-\delta_k\right)+\delta_k\right]S^{ji}\left(\frac{N^jh^j}{N^ih^i}\right),$$

$$\tau_c^ic^i + \tau_w^i(1-\epsilon)y^i + \left[\tau_{rD}^iS^{ii}\eta^i+\tau_{rN}^iS^{ji}\left(\frac{N^jh^j}{N^ih^i}\right)\right]\left(\frac{\epsilon y^i}{k_y^i}-\delta_k\right) + \tau_{rF}^i(1-\tau_{rN}^j)S^{ij}\left(\frac{\epsilon y^j}{k_y^j}-\delta_k\right)$$
$$= g^i + T^i,$$

$$\textit{where } y^i = A(k_y^i)^\epsilon(n^i)^{1-\epsilon},\quad k_y^i = \eta^iS^{ii}+S^{ji},\quad k_h^i = (1-\eta^i)S^{ii},$$

$$\beta^i = \beta(1+g_N^i)^\xi(1+g_h^i)^{1-\sigma},\quad R_h^i = \frac{g_h^i+\delta_h}{1+g_h^i},\quad R_N^i = \frac{g_N^i+\delta_N}{1+g_N^i}.$$

Proposition 1 introduces one additional equation that should hold in the long run, i.e.,

$$(1+g_N^A)(1+g_h^A) = (1+g_N^B)(1+g_h^B).$$

Together, they constitute 19 equations in 19 unknowns, viz., (c^i,n^i,e^i,η^i,S^{ii},S^{ij},g_h^i,g_N^i) (i = A,B; j = B,A) plus the steady state ratio of 'total' human capitals N^Bh^B/N^Ah^A and 2 policy variables, one for each country. (Each policy variable acts as the compensating factor to balance the fiscal budget in its country, given the values of the other policy variables.)