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FACTOR MOBILITY AND INCOME GROWTH: TWO CONVERGENCE HYPOTHESES

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ABSTRACT

While technologies and policy fundamentals are presumably different internationally, inducing differences in growth rates, capital mobility is shown to be a powerful force in achieving complete growth *rate* equalization across countries. We provide evidence in support of this effect, showing that restrictions on capital flows tend to make individual country growth rates more divergent. In the context of regional growth, however, labor mobility is shown to be capable of generating income *level* equalization across regions in the presence of knowledge spillovers. Some supporting evidence is found for this effect, showing that restrictions on labor flows tend to make individual region/country per capita income more divergent.

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I. Introduction

Long term economic growth has long been a subject of major interest in economics for theorists, empiricists, and policy makers.[1] Solow (1956,1957) put forth the role of technical change in generating a positive rate of growth of per capita output, but the long run growth rate in his model is *a priori* exogenously determined. Recent works, such as Romer (1986) and Lucas (1988), endogenize some of the fundamental sources of growth (such as human capital formation and technical progress) to generate sustainable growth in per capita output.[2]

With identical technologies and policy fundamentals, countries with different capital and/or labor endowments will exhibit the same income growth rates in the long run in both exogenous and endogenous growth frameworks with and without factor mobility.[3] With cross country differences in policy fundamentals, however, growth rate differences could arise. Under such circumstances, factor mobility will help resurrect equality in income growth. One important difference between the exogenous and endogenous growth theories is that, while income levels will also be equalized across countries in the long run in the exogenous growth context with identical technologies and policy fundamentals, the same may not be true in its endogenous growth counterpart. In particular, long run income levels depend on initial

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[1]Ramsey (1928), Harrod (1939), von Neumann (1945), and Domar (1947) made pioneering contributions to the theories of economic growth. Stylised facts were compiled by Abramovitz (1956), Denison (1962), and Kuznets (1966). The rate of capital accumulation (through savings) and the rate of growth of the labor force (commonly considered as identical to the rate of population growth) were the major growth determinants.

[2]Other related growth issues are dealt with in what is by now a voluminous literature. Among the works in this area are Becker, Murphy, and Tamura (1990), Stokey (1991), Grossman and Helpman (1991), Jones and Manuelli (1990), Rebelo (1992), King and Rebelo (1990), and Tamura (1991).

[3]As Lucas (1988) puts it, *"[i]n the absence of differences in pure technology ..., and under the assumption of no factor mobility, the neoclassical model predicts a strong tendency to income equality and equality in growth rates, tendencies we can observe within countries and, perhaps, within the wealthiest countries taken as a group, but which simply cannot be seen in the world at large. When factor mobility is permitted, this prediction is powerfully reinforced." (pp.15–16)*

endowments in the latter framework. For these income levels to be equalized across countries/regions in the long run, it is crucial to have international/ interregional knowledge spillovers facilitated by factor mobility.

In this paper, we emphasize the differential roles of capital mobility and labor mobility in the rate- and level-equalizing processes. 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 United States) and among neighboring countries with close economic and political ties (such as countries in the European Union). For this reason, labor mobility is perhaps more relevant for regional growth.

The paper puts forth two convergence hypotheses and confronts them with international and interregional cross section data. The hypotheses are derived in a model-free way, using for the most part national accounts identities and key features of the standard preference-production structure. To the best of our knowledge, little evidence has been brought to bear on the effect of factor mobility on long run convergence. Given the data limitations, our empirical work could be viewed as a 'first attack' on these issues.

The rest of the paper is organized as follows. In Section II, we analyze the role of capital mobility in explaining the diverse growth performance across countries and derive our first convergence hypothesis. In Section III, we provide a formal proof of this hypothesis in the context of a stylized endogenous growth model. The hypothesis is confronted with cross country data in Section IV so as to provide evidence on the growth-equalizing effect of capital mobility. In these sections, we consider only the equalization of income growth rates across countries. Section V then highlights the effect of labor mobility in the equalization of income levels and derives our second convergence hypothesis. In Section VI, we provide

a formal proof of this latter hypothesis in the stylized growth model. This hypothesis is then tested against international and interregional cross section data in Section VII. Concluding remarks are contained in Section VIII.

II. Capital Mobility and Convergence in Income Growth Rates

Let us consider the case where capital is freely mobile but labor is not. 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. Over time, such cross-border capital flows will equalize the MPKs prevailing in all countries.[4]

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 equilibrium. We shall follow the convention in the growth literature and identify *long run* growth with *balanced* or *steady state* growth. An empirically relevant steady state world equilibrium will involve positive net capital flows from some countries to some other countries.[5] For growth to be *balanced* in all countries, the net capital flow of each country

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[4]In the short run, such capital movement may shorten or lengthen the transition paths of the two countries relative to their autarky transition paths. Barro, Mankiw, and Sala-i-Martin (1992) examine how capital mobility affects the speed of converging from the transition path to the steady state growth path. Stokey (1993) has also studied the transitional dynamic behavior of open economies with free capital flows by numerical simulation in a model of development with capital and skilled and unskilled labor.

[5]Without further restrictions, two other situations are possible in the long-run: (a) all capital in the world resides in one single country; and (b) no cross-border capital flows (i.e., back to autarky). Both are unrealistic cases. We shall make some assumptions to eliminate them 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 in all respects, capital flows would not have taken place in the first place. Suppose some fundamental asymmetry (such as national tax rates) is the factor that first induced cross-border capital flows. Further suppose that these countries were travelling along their steady state growth paths initially. Should these fundamentals remain different, the driving force that initiated capital movement to begin with will be reactivated if the countries revert to their long-run autarky growth paths. As such, (b) can also be ruled out. The only empirically interesting case that remains is the one that involves non-zero flows.

must be growing at the same rate as its total income. But since the capital inflow of one country is equal to the capital outflow of another country, the balanced growth restriction forces the *total* income growth rates to be uniform across countries in the long run, i.e.,

Hypothesis 1: *Along the balanced growth path with nonzero net capital flows, the GDP growth rates will be equal across countries.*

To understand this hypothesis better, consider the national income identities facing two countries A and B:

$$C_t^A + I_t^A + G_t^A + TB_t^A = GDP_t^A; \text{ and}$$
$$C_t^B + I_t^B + G_t^B + TB_t^B = GDP_t^B,$$

where C_t^i, I_t^i, G_t^i, and TB_t^i are the consumption, investment, government expenditure, and trade balance surplus in country i (i = A,B) at time t. The trade balance surplus is equal to the negative of the surplus in the capital account of the balance of payments (excluding capital flows corresponding to debt service). Dividing the left hand sides of the two equations by their corresponding right hand sides, we have

$$\frac{C_t^A}{GDP_t^A} + \frac{I_t^A}{GDP_t^A} + \frac{G_t^A}{GDP_t^A} + \frac{TB_t^A}{GDP_t^A} = 1; \text{ and}$$
$$\frac{C_t^B}{GDP_t^B} + \frac{I_t^B}{GDP_t^B} + \frac{G_t^B}{GDP_t^B} + \frac{TB_t^B}{GDP_t^B} = 1.$$

Along the balanced growth path, all terms in the above equations must be time-invariant, implying that the numerator and denominator in each term must grow at the same rate. But for a two-country world economy, $TB_t^A = -TB_t^B$. Thus, they must grow at the same rate. It then follows that their corresponding denominators (i.e., GDP^A and GDP^B) must also grow at that rate. Hence, the equalization of long run *total* GDP growth rates across countries.

Note, however, that since this result is derived solely from the national income identities, it is not model-specific.

III. An Example Economy: Capital Mobility

Although Hypothesis 1 is not model-specific, we introduce an example here in order to link it to the endogenous growth literature. This example will also be used when we get to the labor mobility issue.

Consider a two-country dynastic world, where each country i (i = A,B) is populated by N_t^i identical agents in period t (t = 0,1,2,...). The representative agent cares about his own consumption c_t^i and people in the population N_t^i. Preferences of the dynastic head of the representative family are assumed to be isoelastic:

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

where β is the subjective discount factor, ξ an altruism parameter, and σ the inverse of the intertemporal elasticity of substitution in consumption. As long as $\xi > 0$, altruism is reflected not only in preference for 'quantity', but also 'quality' (as measured by their living standard in terms of consumption per capita), of children—since, with positive ξ, there is weight given to quantity, but the weight on the consumption term is magnified as well. Observe that if $\xi > 1-\sigma$, then there will be a relative bias in preference towards quantity; whereas if $\xi < 1-\sigma$, the bias will be in the opposite direction.[6]

There are N_0^i members in the representative household, and the size of the family is assumed to grow at the exogenous rate g_N^i, i.e., $N_t^i = N_0^i(1+g_N^i)^t$. In each period t, each

[6]See Razin and Yuen (1995b) for the Millian and Benthamite interpretations of this utility function and their implications for the tradeoff between population and income growth.

household member is endowed with one unit of non-leisure time, to be split between two time-consuming activities—working (n_t^i for number of worked hours) and learning in schools (e_t^i for education). He/she also possesses h_t^i of human capital and S_t^i/N_t^i of physical capital carried over from period t−1 (given h_0^i and S_0^i/N_0^i at t=0). He/she has to decide how much capital (S_{t+1}^i) to be carried forward to the ensuing period. Under capital mobility and absent adjustment costs, new stocks of physical capital can freely be transformed into financial capital and invested abroad. We denote the amount of physical capital invested abroad by S_{t+1}^{ij} and that at home by S_{t+1}^{ii} (i = A,B and j = B,A), then $S_{t+1}^i = S_{t+1}^{ii} + S_{t+1}^{ij}$ is the total investement at time t.

Newly acquired effective labor ($H_t^i = n_t^i N_t^i h_t^i$) and physical capital ($K_t^i$) accumulated from the previous period are supplied to the labor and capital markets in each period at the prevailing competitive wage (w_t^i) and rental (r_t^i) rates.

The dynamics of the growth engine are determined as follows. The schooling activity contributes to human capital growth:

$$h_{t+1}^i = B(e_t^i)^\gamma h_t^i \qquad (2)$$

where B is the knowledge efficiency coefficient and γ the productivity parameter.

Final output is produced by competitive firms using physical capital (K_t^i) and total effective labor (H_t^i) via a Cobb-Douglas-type technology with a Lucas (1988)-type spillover effect (captured by the average level of human capital, $\bar{h}_t^i$): $Y_t^i = A(K_t^i)^\varepsilon (H_t^i)^{1-\varepsilon} (\bar{h}_t^i)^{\tilde{\varepsilon}}$, where A is the production coefficient, ε the output share of capital, and $\tilde{\varepsilon}$ the externality parameter. (This spillover effect will be an important feature in deriving Hypothesis 2 in the labor mobility section below.) Implicit in the specification of effective labor (H_t^i) as the product of worked hours (n_t^i), number of workers (N_t^i), and their human capital level (h_t^i) is the assumption of perfect substitutability among these three objects in the supply of labor. Under

perfect capital mobility, the capital input in country i can be obtained in one of two ways: either through forgone domestic consumption or through inflow of capital from abroad, i.e., $K_t^i = S_t^{ii} + S_t^{ji}$. Since capital can flow in either direction, GNP_t^i equals GDP_t^i plus net capital income from abroad, i.e., where r_t^i is the rate of return on capital in country i. Income earned is either consumed ($N_t^i c_t^i$) or saved in the form of physical capital accumulation I_t^i (= S_{t+1}^i). Hence, we can write country i's resource constraint as:

$$N_t^i c_t^i + S_{t+1}^i = A(K_t^i)^{\epsilon}(H_t^i)^{1-\epsilon}(\bar{h}^i)^{\tilde{\epsilon}} + r_t^j S_t^{ij} - r_t^i S_t^{ji}. \qquad (4)$$

For simplicity, full depreciation is assumed for K_t^i and h_t^i in each period. Since exists essentially only one good in each period, we can add up the resource constraints of both countries to get the total world resource constraint: $C_t + S_{t+1} = Y_t$, where $C_t = N_t^A c_t^A + N_t^B c_t^B$, $S_t = S_t^A + S_t^B$, and $Y_t = Y_t^A + Y_t^B$.

To prove Hypothesis 1, suppose without loss of generality that capital flows from B to A net (since, in a full certainty model, equilibrium capital flows will be unidirectional.) Consider the resource constraint facing the home country with all the growing variables detrended by dividing the whole equation through by $N^A h^A$:

$$c^A + (1+g_N^A)(1+g_h^A)S^A = A(k^A)^{\epsilon}(n^A)^{1-\epsilon}(\bar{h}^A)^{\tilde{\epsilon}} - r^A S^{BA}\left(\frac{N_t^B h_t^B}{N_t^A h_t^A}\right).$$

The last term can be rewritten as:

$$-r^A S^{BA}\left(\frac{N^B h^B}{N^A h^A}\right)\left(\frac{(1+g_N^B)(1+g_h^B)}{(1+g_N^A)(1+g_h^A)}\right)^t$$

where $N^i = N_t^i/(1+g_N^i)^t$ and $h^i = h_t^i/(1+g_h^i)^t$ are the detrended steady state levels of population and human capital respectively in country i (i = A,B). Note that this term will depend on

time t and thus be non-stationary unless $(1+g_N^A)(1+g_h^A) = (1+g_N^B)(1+g_h^B)$, implying equality of the growth rates of GDP g_Y^i in A and B along the steady state growth path.

IV. Evidence on the Growth-Equalizing Effect of Capital Mobility

To confront Hypothesis 1 with data is somewhat challenging since rigorous evidence on the degree of capital mobility is hard to come by. We start, therefore, with an 'eyeball' approach to examine some further implications of Hypothesis 1.

The above hypothesis does not necessarily imply equalization in the rates of growth of income per capita.[7] Since per capita income equals total income divided by the size of the population, we can decompose the *total* income growth rates into the *per capita* income growth rates and *population* growth rates: $(1+g_Y) = (1+g_N)(1+g_y)$, where g_x is the growth rate of variable x, N population, y per capita income, and Y total income. Together with Hypothesis 1, 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.*

To shed light on these implications, we turn to the data. Among the development patterns summarized by Romer (1989), the negative correlation between population growth rates (g_N) and the levels of per capita income (y) is classified as one stylized fact. But similar correlation between population growth (g_N) and per capita income growth (g_y) as suggested

[7]The possibility of divergence in per capita income growth rates even when output (or total income) growth rates are equalized under capital mobility is demonstrated in Razin and Yuen (1995a,1995c).

by implication (1) is not as clear. See Table 1 for some summary figures.

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.[8] In fact, both of these correlations tend to be negative during the more advanced stage of development. But since we are concerned about the long run average growth rates across *all* countries (not restricted to developed or less developed countries alone), we show in Figure 1 below the correlation between g_N and g_y, incorporating countries under all phases of development.

The downward sloping regression line fitted through the points in the scatter diagram indicates that, by and large, the two growth rates are negatively correlated. As a further confirmation, we find that the correlation coefficient between g_N and g_y is $-.27$. Since countries that exhibit low rates of growth of income will turn out to have low levels of income over time, the two types of correlation mentioned above—that between population growth and income level and that between population growth and income growth—may not be all that distinguishable.[9]

Implication (2) does not follow directly from, and is actually a weaker form of, Hypothesis 1. It takes account of the fact that, in the real world, capital movements are not

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

[9]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. See a rough indication of this in Table 1.

frictionless and 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 from the data for the strict version of this hypothesis. However, if we average the growth rates in every country over longer time periods, these fluctuations will be smoothed out so they will be better approximations to the long run. Then, the weak version says that the average total income growth rates should be less variable than the average per capita income growth rates across countries.

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 Hypothesis 1 holds exactly. Simple eye-ball observation indicates that there is less variability in the total GNP growth rates across countries than their per capita counterpart.[10] 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] indeed falls short of the CV in the per capita income growth rates [= 1.35]. In a rough sense, therefore, implication (2) is corroborated 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 Hypothesis 1. Since perfect capital mobility is a precondition for this hypothesis, we expect these implications to find stronger support from countries with less restrictions on capital flows. This hunch is examined more rigorously below.

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[10]The proposition suggests that we should look at GDP, rather than, GNP growth rates. But the World Development Report displays GNP figures only. In any case, the growth rates of GDP and GNP should not differ too much over such a long time horizon.

IV.A Choice of Capital Mobility Indicators

Many of the recent growth theories have been motivated by informal examination of data on savings, education, R&D, political stability, and other variables. This is because the nature of cross country data does not permit more sophisticated estimation and testing of the growth-generating mechanisms as exemplified by these theories. A more rigorous (than simple 'eyeballing') empirical analysis in this section focuses on the cross country variations in the degree of capital mobility as an explanation of the cross country variations in income growth rates.

The difficulty in getting a good measure of the degree of capital mobility is well-known. For example, the IMF's annual reports on exchange arrangements and exchange restrictions have data pertaining to capital controls. However, the variables in these datasets (such as surrender of export proceeds required and payments arrears) are binary indicators and do not take into account the severity of control. An alternative indicator is the cross country interest rate differentials. Unlike the onshore and offshore interest differentials for a few industrialized countries (which are denominated in the same currencies), the data for most other countries are plagued by problems of different currency denominations, different risk premia, etc. For these reasons, the interest rate differential is not a good indicator of the restrictions on capital mobility either.

Our choice of the capital mobility indicator consists of: (1) the total external debt as a percentage of GNP, and (2) the concessional debt as a percentage of GNP. Total external debt is defined as the sum of public, publicly guaranteed, private non-guaranteed long term debt, use of IMF credit, and short term debt drawn at year end, net of repayments of principal and write-offs. Concessional debt measures the borrower's receipt of aid from official lenders at concessional rates (i.e., loans with an original grant element of 25% or more).

The idea behind the first indicator is that heavily indebted countries often restrict the movement of financial capital in many different ways. By the same token, less heavily indebted countries usually liberalize their international capital transactions. The second indicator conveys information about foreign aid. Countries that rely on aid from official lenders are expected to impose more capital controls in order to prevent capital flight. On the contrary, developed countries with relatively free capital markets are almost never recipients of such debt.

IV.B Data Sources and the Regression Equation

Our empirical work uses data from two different sources. National accounts (including income levels and growth rates) data are taken from the Summers and Heston Penn World Table (Mark 5). The data span 1950 through 1988 for 138 countries. The debt data is drawn from the World Bank's World Data CD-ROM. The sample comprises 125 countries with data starting from 1970 for concessional debt and 1971 for external debt. The sample period we choose for the regression below is thus shortened to 1970–88.

One limitation in the capital mobility data is the lack of complete time series: the World Bank only has records on the debt variables starting from the early 1970s, and they are missing for the high-income industrialized countries. Believing that these countries are rarely recipients of foreign aid, we can safely assume that their concessional debts are zero.

We now provide a brief discussion of the debt statistics in our sample. Figure 3 portrays the mean levels of total external debt–GNP ratios and concessional debt–GNP ratios for the period 1970–92. Both ratios have been rising over time: from 23% to 92% for the former, and from 9% to 40% for the latter. They show especially rapid increases in the post-

1980 period, indicating a trend towards more restrictions on capital mobility. Although the means and variances of the cross country distributions of these debt-output ratios (not shown) have been increasing over time, this is due mainly to the sharp rise in these ratios in a few heavily indebted countries.

To test the hypothesis that long run total income growth rates will be equalized under capital mobility, we set up a linear regression:

$$Y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3,$$

where Y is the squared deviation of the individual country cyclically adjusted (5-year moving average) total income growth rates from their common global or 'club' counterpart (i.e., $g_Y^i - (\Sigma_i g_Y^i Y^i)/(\Sigma_i Y^i)$),[11] X_1 the capital mobility indicator, X_2 the annual per capita income level, X_3 a 6x1 vector of regional dummies, and $(\alpha_0,\alpha_1,\alpha_2,\alpha_3)$ are the corresponding coefficients. The six regional dummies are: Africa, Central and North America, South America, Asia, Europe, and Oceania.

Since our main focus here is on the growth-equalizing effect of capital mobility (X_1), the null according to our hypothesis is $\alpha_1 > 0$. The income per capita variable (X_2) and the regional dummies (X_3) are introduced to capture systematic country-specific and region-specific effects, respectively, for adjustment purposes.[12]

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[11]We have also experimented with the absolute deviation (i.e., square root of the squared deviation), and found similar results.

[12]Lucas (1988) poses the *problem of economic development* as the problem of accounting for the observed diversity in the levels and rates of growth of income across countries and over time). Here, we take for granted the various possible level- and growth-diverging forces such as country/region-specific shocks and government policies can be captured by the adjustors, X_2 and X_3, in our regression equations, and address the issue of the income level-equalizing and growth-equalizing effects of factor mobility.

IV.C Findings

Table 2 reports our key findings for the external-debt indicator and concessional-debt indicator respectively. We split the sample into four 'clubs' according to their income levels: high, middle-high, middle-low, and low. Alternative specifications according to deviations of individual country growth rates from their common world or 'club' averages are displayed in each table.[13]

The external debt regressions indicate a significant positive effect of the capital restrictions indicators on growth rate divergence after controlling for income levels and regional dummies. The coefficients associated with the capital flow restrictions indicators are slightly more pronounced in the case of the club average relative to that of the world average. The concessional debt regressions are not revealing, but cannot reject Hypothesis 1 either. The effects of the regional dummies suggest that Africa and Central and North America are diverging significantly either from the world average or the club average, after controlling for the degree of capital mobility and income levels.

Overall, our results support the hypothesis of total income growth rate convergence under capital mobility.

V. Labor Mobility and Level Convergence

Let us now turn to the other extreme case where labor is freely mobile but capital is not. Labor mobility opens up the possibility of convergence in income levels across countries or regions of a country.

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[13]We have also experimented with the hypothesis that only countries whose external debt to GNP ratio was above a certain threshold level imposed restrictions on capital flows, which led to diverging growth rates. When we consider threshold levels of 60% and 70%, the regression coefficients of the capital restrictions indicators were found to be statistically significant for absolute deviations from the 'club' averages.

The new growth theory has renewed the interest among economists and policy makers about whether or not the levels of income in different countries converge over time. This has been a subject of both intensive and extensive empirical research for more than a decade. The initial empirical strategy was to relate average income growth rates of countries to their initial income levels. A negative coefficient on initial income levels that has almost invariably been found in the data is taken to imply convergence. [See Baumol (1986) and De Long (1988).] These studies use essentially international cross section data (although some of them augment these data by a few time series observations.) Baumol (1986) and Baumol and Wolff (1988) conclude that levels of income across industrial countries seem to have converged, mid-income countries to exhibit moderate convergence, and low income countries to have diverged.

Barro and Sala-i-Martin (1991,1992) spark off a renewed interest in the convergence issue by extending the scope of empirical analysis. They address the key economic issue of whether poor countries or regions tend to grow faster than rich ones. They also use the Solow-type neoclassical growth model as a framework to structure their empirical analysis and to study the speed of convergence. Their findings seem to support convergence of both regions and countries, with a relatively robust estimate of the speed of convergence. These findings are still based on essentially cross sectional data with limited number of time series observations.

There is a difficulty in the interpretation of the negative correlation between average annual income growth rates and initial income levels, based almost exclusively on cross sectional observations. Friedman (1992) and Quah (1993) question whether the negative coefficient on initial income levels should be taken as indication of convergence. Very much like Hotelling's (1933) criticism on a similar evidence purporting to show that business

enterprises were tending to converge in size, this level convergence analysis may suffer from the classical Galton Fallacy of 'regression towards the mean'. Expanding on different meanings of convergence, Quah (1993) puts forward the notion of whether the cross sectional dispersion of *per capita* incomes diminishes over time. The key message from his calculations is that cross section distributions of incomes do not appear to be collapsing; they seem to be fluctuating over time.

Ben David (1994) follows Quah (1993) by examining the dispersion of *per capita* incomes across countries within three income groups: high, middle, and low. He finds that the group of wealthy countries is characterized by 'upward convergence', where the poor members catch up with the richer members in the group. The group of extremely poor countries exhibits 'downward convergence', where the richer members dwindle down to join the poorer members in the group. Notwithstanding the progress made in the empirical analysis of this issue, the kind of evidence on *level* convergence is still mixed at this stage.

The mechanism by which long term growth can be sustained are by now relatively well-understood. In contrast, the empirical work cited above on level convergence is essentially based on the Solow-style exogenous growth model. Conceptually, this latter framework permits convergence in income levels (assuming identical production technologies due to the possibility of technology transfer across countries in the long run). In the alternative endogenous growth framework, however, level convergence can only be achieved under fairly stringent conditions. We show that labor mobility is essential for such global equalization.

We now present a mechanism through which labor mobility can bring about income coefficient on initial income levels should be taken as indication of convergence. Very much like Hotelling's (1933) criticism on a similar evidence purporting to show that business

(1988,1990).[14, 15] In particular, suppose that knowledge spillovers affect production in the same way as modelled by Lucas (1988) and as specified in Section III above, i.e., $Y_t^i = A(K_t^i)^\epsilon(H_t^i)^{1-\epsilon}(\bar{h}_t^i)^{\tilde{\epsilon}}$. In other words, an individual's decision to accumulate human capital will augment production in two ways: (a) through his own improved labor quality; and (b) through a spillover effect that raises the average productivity of his co-workers.

Consider two isolated economies that have identical preferences and technologies, but possibly different endowments of physical and human capital. Even without capital mobility, interest rates will be equalized across these two economies in the long run (i.e., along their autarky balanced growth paths) as their steady state physical capital-human capital ratios converge to the same value. In the presence of the Lucas-type external effect, wage rates in these two economies will differ as long as the skill levels of their workers are different. With labor mobility, workers will naturally move from the low wage (human-capital-poor) region—call it region B—to the high wage (human-capital-rich) region—call it region A. Since labor

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[14]A motivation for analyzing production externality has to do with the seeming international differentials in marginal products of capital across regions. Based on naive capital-labor ratio calculations, the real wage in the United States is about 15 times higher than that in India (see Summers and Heston (1988)). This is plausibly a consequence of the marked difference in skills or human capital between American workers and Indian workers. Correcting for these differences, Lucas (1990) finds that the wage per unit effective labor in the US is still 3 times higher than that in India. Obviously, Indian labor can by no means enter freely to the US so as to eliminate this observed wage differential. But, with identical technologies, when labor has a higher marginal product in the US, it must be the case that capital has a higher marginal product in India. According to Lucas's calculations, the MPK in India is 5 times higher than the MPK in the US. He then correctly poses the puzzle: why capital from the US and other rich countries does not flow into India and other less developed economies. To some extent, the puzzle can be resolved by resorting to such factors as socio-political unrest and technological risk. Based on the new developments in growth theory, Lucas suggests an alternative explanation. He contends that there is no essential difference in the MPKs between the US and India. Instead, there is only a productivity difference that is generated by an external effect from human capital. The idea is that investment in human capital does not only augment the effective labor supply of the worker who made the investment, but also contributes to the productivity of all other workers and capital alike. Taking account of this external effect may resolve the Lucas (1990) puzzle.

[15]This external effect implies that, without barriers, capital and labor will move in the same direction, contrary to the prediction of the standard theory (in the absence of the external effect). Atkeson and Bayoumi (1993) provide evidence from regions of the US which is consistent with this framework. They compare measures of interregional capital flows (as indicated by differences between regional income and product levels) and interregional population movements. Their data show that, by and large, population flows mirror the flows of capital. It appears, therefore, that labor and capital have been flowing to the same areas for the past two decades rather than moving in opposite directions as the standard theory predicts. See their Tables 2 and 3.

will flow from region B to region A, the fraction of domestic effective labor working in region A, n^A, equals 1 and the corresponding fraction in region B, n^B, lies between 0 and 1. The effective work force in region B is $N^B n^B h^B$ and that in region A is $N^A h^A + N^B(1-n^B)h^B$. The average levels of human capital are $\bar{h}^A = \theta h^A + (1-\theta)h^B$ and $\bar{h}^B = h^B$ in equilibrium, where $\theta = N^A/(N^A+N^B)$.

Suppose that while some workers from region B choose to work in region A, they continue to accumulate their human capital in their own region. Although the extent of knowledge spillovers may be limited by national boundaries, labor mobility provides an indirect channel of productivity transmission across regions.[16] This is because workers from region B can enjoy the fruits of the knowledge externality while working with the more skilled workers in region A, and then transmit this superior knowledge to the region B people during the process of human capital accumulation. In other words, these workers can be viewed as 'messengers' of technological progress. Over time, this knowledge transmission will lead to equalization of wage rates as well as levels of human capital and income per capita in the two regions. Hence, the following hypothesis.

Hypothesis 2: *Along the balanced growth path with nonzero labor flows, the income levels will be equalized across regions.*

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[16]Our analysis here may look similar to Tamura (1991). There, he shows that a spillover effect in the human capital formation technology provides below-average human capital agents with a higher rate of return on investment than above-average human capital agents, so that the former will eventually catch up with the latter. But since he deals with heterogeneous agents in a closed economy, direct application of his convergence result to an open economy (interpreting his agents as countries) will require breaking the national boundaries as barriers to knowledge spillovers as well. But if spillovers were worldwide, convergence would occur even without mobility of either factor. We therefore conjecture that convergence in levels will not obtain under the Tamura-type externality if such spillovers are somehow confined only within each country. In our case, although the extent of knowledge spillovers is limited by national boundaries, labor mobility provides a source of leakage for the Lucas-type external effects through some sort of on-the-job learning. So the main difference between the two forms of spillovers is that while initial income differences may get dampened over time under the Lucas-type externality, the same will not hold for the Tamura-type. Two alternative forms of externality, Parente and Prescott (1992) and Tamura (1993), can also produce income level convergence without allowing for cross-border spillovers.

VI. An Example Economy: Labor Mobility

In order to provide a formal proof for Hypothesis 2, we now return to the example economy in Section III. In more technical terms, Hypothesis 2 states that

Along the steady state growth path with nonzero labor flows and $\varepsilon > 0$, either
(a) $g_h^A = g_h^B$ *and* $g_N^A = g_N^B$ *(with* $0 < \theta < 1$*) and* $h^A = h^B$*, or*
(b) $g_h^A > g_h^B$ *and* $g_N^A < g_N^B$ *(with* $\theta = 0$*) and* $\bar{h}^A = h^B$ *when* $\xi = 1-\sigma$.

Proof: Along the global steady state growth path, $g_K^i = g_Y^i$ (i = A,B) and the ratios of the cross-border labor income $w^A(1-n^B)N^Bh^B$ to both GDP^A and GDP^B must be constant. Given the Cobb-Douglas production function, these balanced growth conditions imply that: $(1+g_N^A)(1+g_h^A) = (1+g_N^B)(1+g_h^B)$, and

$$\frac{1+g_Y^A}{1+g_Y^B} = \left(\frac{1+g_h^B}{1+g_{\bar{h}}^A}\right)^{\frac{\xi}{\epsilon}} \quad \textit{where } 1+g_{\bar{h}}^A = \frac{(1+g_N)(1+g_h)}{\theta(1+g_N^A)+(1-\theta)(1+g_N^B)}.$$

From the Cobb-Douglas function and the equality $g_K^i = g_Y^i$ (i = A,B), we also have

$$\frac{1+g_Y^A}{1+g_Y^B} = \left(\frac{1+g_{\bar{h}}^A}{1+g_h^B}\right)^{\frac{\xi}{1-\epsilon}}.$$

The following can be derived by combining the two conditions above.

$$g_{\bar{h}}^A = g_h^B \quad \textit{so that} \quad \begin{cases} (a) \;\; g_N^A = g_N^B \;\; \& \;\; g_h^A = g_h^B \;\; (0<\theta<1) \\ (b) \;\; g_N^A < g_N^B \;\; \& \;\; g_h^A > g_h^B \;\; (\theta=0) \end{cases}. \tag{5}$$

Along the equilibrium balanced path, the fundamental growth equation *a la* Rebelo (1992) can be expressed as:

$$\left(\frac{1+g_h^A}{1+g_h^B}\right)^{\xi-(1-\sigma)} = \frac{r^A}{r^B} = \frac{z^B}{z^A} \quad \text{where } z^A = \frac{K^A}{N^A h^A + N^B h^B (1-n^B)} \;\&\; z^B = \frac{K^B}{N^B h^B n^B}. \quad (6)$$

where, as in Section III, ξ reflects the consumer's preference for the quantity of children, and σ reflects the consumer's preference for the quality of children. The second equality follows from $r^i = \varepsilon w^i/(1-\varepsilon)z^i$ and the wage equality condition: $w^A = w^B$.

In case (a), $g_h^A = g_h^B$, leading to equality of interest rates and hence capital-effective-labor ratios. Substituting back into the wage equality condition, $z^A = z^B$ implies that $h^B = \bar{h}^A = \theta h^A + (1-\theta)h^B$, so that $h^A = h^B$ for $\theta \in (0,1)$. This proves part (a) of the proposition.

In case (b), $\theta = 0$ also implies that $\bar{h}^A = h^B$. Together with the wage equality condition, this means that $z^A = z^B$ and $r^A = r^B$. (6) then indicates that $g_h^A = g_h^B$, which contradicts (5), unless $\xi = 1-\sigma$. This concludes the proof of part (b) of the proposition.

VII. Evidence on the Level-Equalizing Effect of Labor Mobility

Even more so than in the case with capital mobility, labor mobility is less than perfect in the real world. According to the labor-mobility-level convergence hypothesis, we should expect to find in the data more convergence in income levels among regions with relatively free labor flows (like states within the US) than among countries with almost no mobility (like the European countries). Our empirical strategy is to contrast income level convergence among the US regions with that among the European countries in order to shed light on that hypothesis.

VII.A Choice of Labor Mobility Indicators

Eichengreen (1990) summarizes unemployment differentials within the European Community and the United States. Figure 4 portrays the dispersion of unemployment rates

for nine regions in the US and nine countries in the EC. All three dispersion measures he considers (i.e., absolute differences, standard deviations, and coefficients of variation) are higher in the EC than in the US. This suggests that interregional labor mobility is greater in the US than in the EC. Another important difference between the US and the EC is the change in the average level of the unemployment dispersion measures over time. While the absolute difference in the US regional unemployment rates rises from less than 2% in the early 60s to more than 5% in the 80s, that for Europe rises from 4% to 10%. It thus appears that the labor markets are also slower to adjust to regional disturbances in Europe than in the US. This is another evidence for greater labor mobility in the US than in the EC. We thus choose the unemployment dispersion measures as indicators of labor mobility (or, more precisely, barriers to mobility) in the regression below.[17] Evidently, these measures capture mobility within (rather than across) the American and European 'clubs'.

VII.B Data Sources and the Regression Equation

Our empirical work uses data from three different sources. Per capita personal income data for regions of the US are drawn from publications of the Bureau of Economic Analysis (BEA) at the US Department of Commerce. (Assuming that nation-wide and state inflation rates are about the same in any given year, we deflate these nominal state income data using the GNP deflators in the US as reported in various issues of the IFS Statistical Yearbook.) Per capita income data for the European countries are obtained from Summers and Heston (1991). Our unemployment dispersion measures are borrowed from Eichengreen (1990)—whose computations are in turn based on unemployment figures from the *Statistical Abstract*

[17]There is some additional evidence on the regional aspects of labor mismatch and their implications for labor mobility in Europe in Padoa Schioppa (1991).

of the United States and the *Eurostat*—as proxies for labor mobility.

We consider nine regions in the US and nine countries in Europe. Regions in the US are grouped according to the Census division, i.e., New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, and Pacific. The European countries in our sample comprise Belgium, Denmark, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, and the UK.[18]

To confront Hypothesis 2 with data, we set up the following regression equation:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3,$$

where y is the squared deviation of the cyclically adjusted levels (5-year moving averages) of *per capita* income of the individual regions or countries from their corresponding (American and European) club average levels, x_1 the labor mobility indicator, x_2 the annual per capita income growth rates of the regions/countries, and x_3 the club dummies, and $(\beta_0,\beta_1,\beta_2,\beta_3)$ the corresponding coefficients. The club dummies are the US and Europe. It should be emphasized that the time series of the left hand side variable are cyclically adjusted, those on the right hand side are not. Thus, our regression results are free from spurious correlation.

Since our focus here is on the level-equalizing effect of labor mobility (x_1), the null according to our Hypothesis 2 is $\beta_1 > 0$. The income growth rate variable (x_2) and the regional dummies (x_3) are introduced to capture systematic region/country-specific effects for adjustment purposes.

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[18]We also experiment with the BEA division as an alternative classification of regions in the US. The eight BEA areas include New England, Mideast, Great Lakes, Plains, Southeast, Southwest, Rocky Mountains, and Far West. The geographically distant regions of Alaska and Hawaii are excluded from our BEA sample. Our results are not sensitive to the regional division of states in the US.

VII.C Findings

Table 3 reports our key findings for the various labor mobility indicators. Unlike the capital mobility regressions (where we consider both deviations from the world and club averages), only deviations of the individual country/region levels of per capita income from their 'club' average are displayed here since mobility of labor between the American and European clubs is very low.

Except for regressions based on the third labor mobility indicator (i.e., coefficient of variation, cv), all specifications in the table indicate a significant positive effect of the labor flow restriction indicators on income level divergence after controlling for growth rates and regional dummies. This is not surprising, given the observed time pattern of cv in Figure 4, which behaves somewhat differently from the other two indicators. The coefficients on the cyclical growth rates variable are insignificant. After adjusting for the labor mobility and growth rate indicators, the club dummies indicate that there are more systematic variations among regions in the US.

Overall, our results provide some support for the labor mobility-income level convergence hypothesis.

VIII. Conclusion

While technologies and policy fundamentals are presumably different internationally, inducing differences in growth rates, capital mobility is shown to be a powerful force in achieving complete growth rate equalization across countries. We provide evidence in support of this effect, showing that restrictions on capital flows tend to make individual country growth rates more divergent.

Income levels vary in a major way both internationally and interregionally due

presumably to differences in factor endowments. This divergence outcome is consistent with the prediction of endogenous growth theories in the absence of factor mobility.

In the context of regional growth, however, labor mobility is shown to be capable of generating income level equalization across regions (in the presence of human capital externality). Some supporting evidence is found for this effect, showing that restrictions on labor flows tend to make individual region/country per capita income more divergent.

However, the supportive evidence for our two hypotheses is not very strong. Due to severe limitations of data on restrictions on capital and labor flows, we cannot perform a sharp test of the two hypotheses at this stage. But we believe that the mechanism uncovered in this paper linking factor flows and growth and income level imbalances is of paramount importance in explaining the growth experience of countries and regions. It will therefore have to be confronted with more refined data in the future.

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Table 1. Levels and Average Annual Growth Rates of (a) Population and (b) GNP per capita

	1991 population (millions)	1991 GNP per capita (dollars)	Average annual growth (percent)					
			1965-73		1973-80		1980-90	
			(a)	(b)	(a)	(b)	(a)	(b)
Low-and middle-income economies	4,528	1,010	2.5	4.3	2.1	2.7	2.0	1.2
Low-income economies	3,127	350	2.5	2.5	2.1	2.6	2.0	4.0
Middle-income economies	1,401	2,480	2.3	..	2.2	..	1.8	0.5
Severely indebted	486	2,320	2.4	5.2	2.3	3.4	2.1	-0.8
Sub-Saharan Africa (excl. South Africa)	489	350	2.7	1.7	2.9	0.9	3.1	-1.3
East Asia and the Pacific	1,667	650	2.6	5.0	1.7	4.8	1.6	6.2
South Asia	1,152	320	2.4	1.2	2.4	1.7	2.2	3.2
Europe and Central Asia	492	2,670	..	..	..	..	0.9	1.4
Latin America and the Caribbean	445	2,390	2.6	4.6	2.4	2.2	2.0	-0.4
Middle East and North Africa	244	1,940	2.8	6.0	3.0	1.7	3.2	-2.5
High-income economies	822	20,570	1.0	3.7	0.8	2.1	0.6	2.3
OECD members	783	21,020	0.9	3.8	0.7	2.1	0.6	2.3
World	5,351	4,010	2.2	2.8	1.8	1.3	1.7	1.2

N.B. Because of incomplete coverage, discrepancies between summed subgroup figures may occur.

Source: Tables A.1 and A.2 of the 1993 World Development Report.

Table 2
Capital Mobility and Growth Rate Divergence

variable	deviation from world average		deviation from club average	
	external debt	concessional debt	external debt	concessional debt
capital restrictions	.0065 (4.33)	–4.00 (–.68)	.0604 (3.36)	–4.03 (–.69)
real income per capita	.0017 (4.11)	–.042 (–1.65)	.0039 (7.20)	–.04 (–1.66)
Africa	10.00 (8.39)	150.52 (.73)	12.81 (8.16)	157.90 (.77)
Central & North America	7.69 (3.69)	262.42 (.90)	9.15 (3.33)	271.98 (.93)
South America	5.24 (2.34)	190.39 (.61)	10.28 (3.48)	205.60 (.66)
Asia	1.57 (0.96)	500.45 (1.93)	–2.34 (–1.09)	505.65 (1.94)
Europe	–3.23 (–.98)	1250.22 (4.19)	3.68 (.85)	1258.47 (4.20)
Oceania	2.60 (.53)	349.68 (.66)	2.40 (.37)	353.80 (.66)
adjusted R-squared	.31	.0082	.41	.0083
degrees of freedom	1248	1865	1248	1865

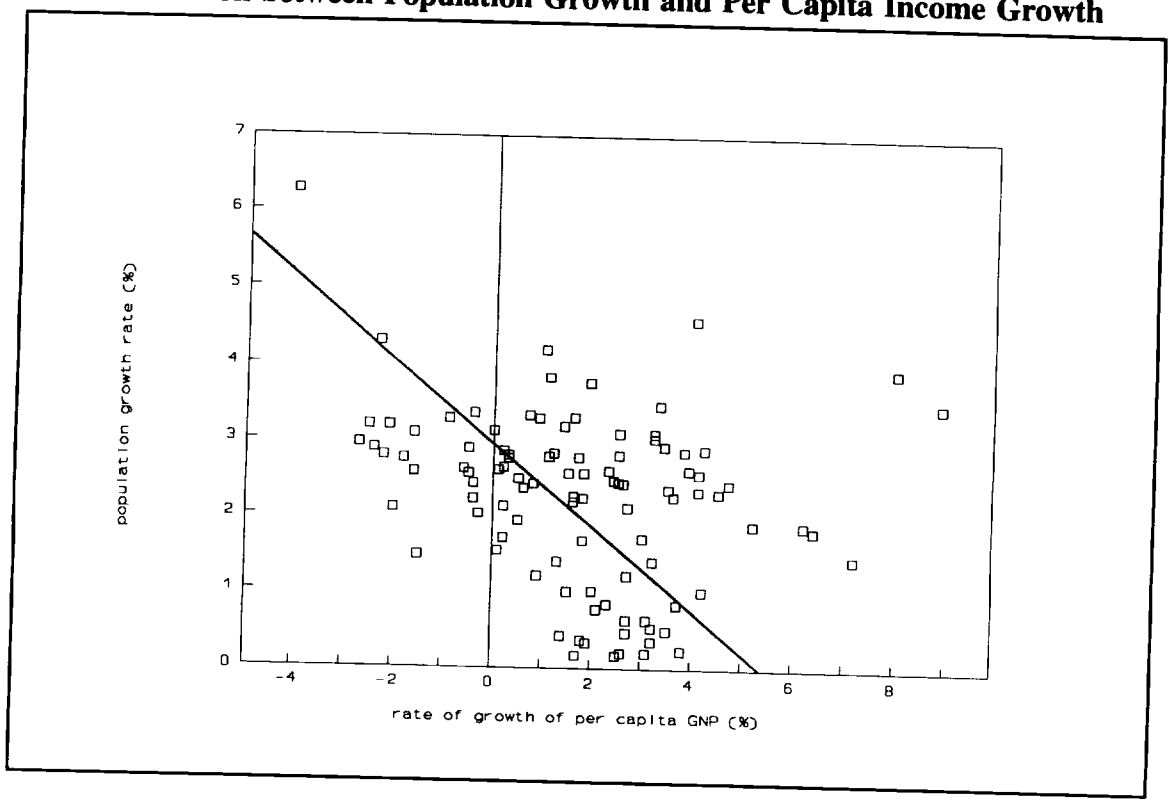
N.B. t-statistics are in parentheses.

Table 3
Labor Mobility and Level Divergence

variable	absolute difference	standard deviation	coefficient of variation
labor restrictions	239829 (2.56)	605085 (2.21)	–181373 (–2.13)
annual income growth	–57933 (–.99)	–65258 (–1.11)	–41824 (–.69)
United States	1205861 (2.78)	1404966 (3.45)	2349433 (8.45)
Europe	757629 (1.18)	817844 (1.16)	3118969 (6.43)
adjusted R-squared	.25	.25	.25
degree of freedom	522	522	522

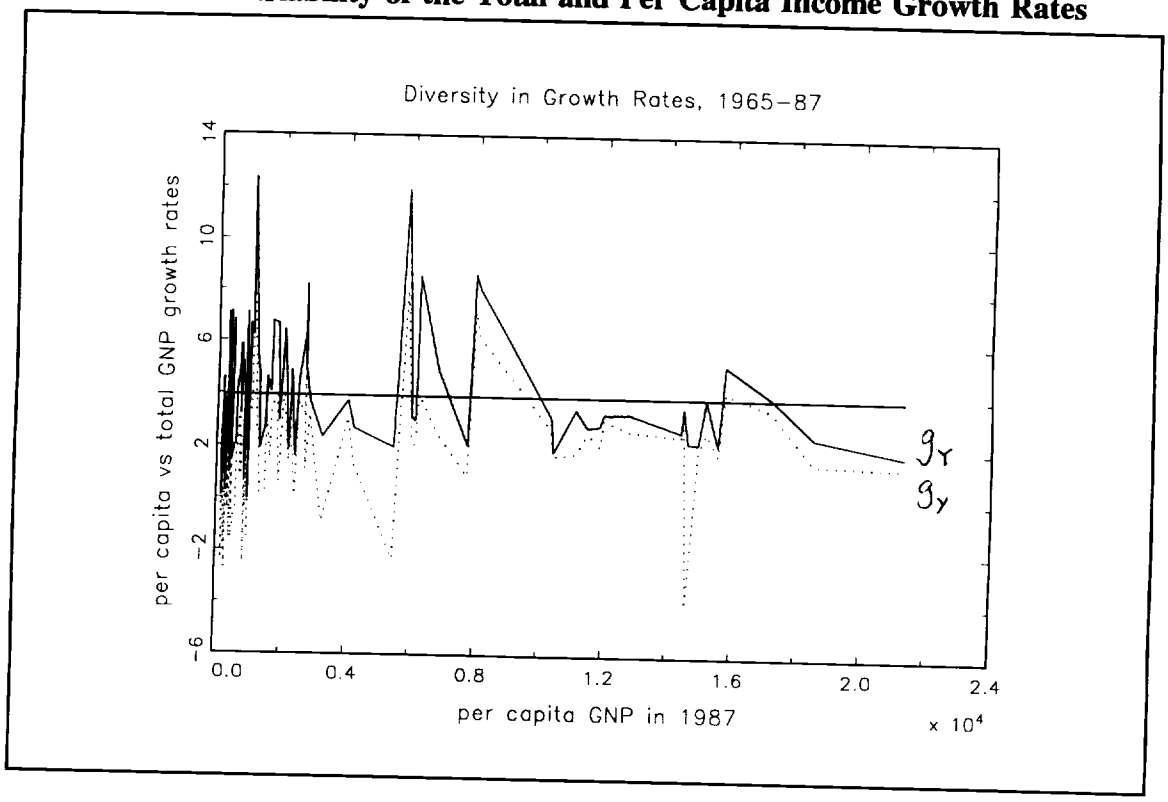
N.B. t-statistics are in parentheses.

Figure 1
Correlation between Population Growth and Per Capita Income Growth



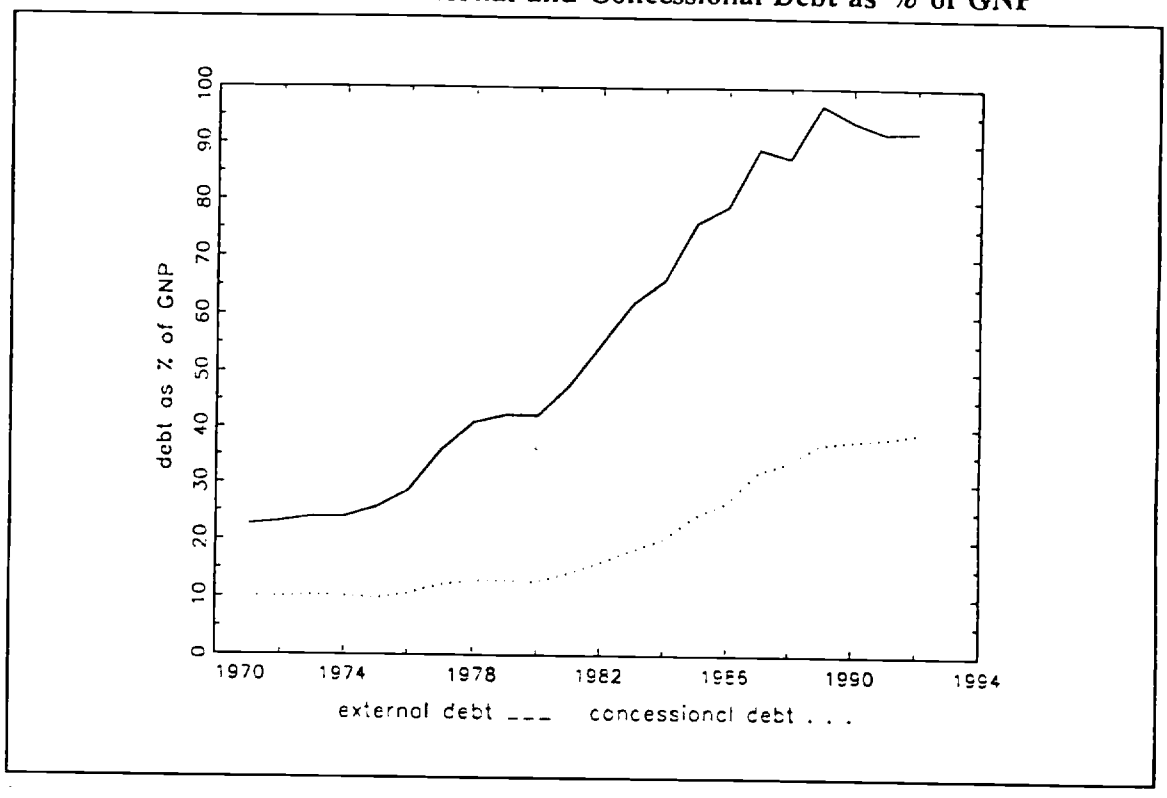
Source: 1965-87 data for the 120 countries (excluding those with missing data) listed in Tables 1 and 26 of the 1989 World Development Report.

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

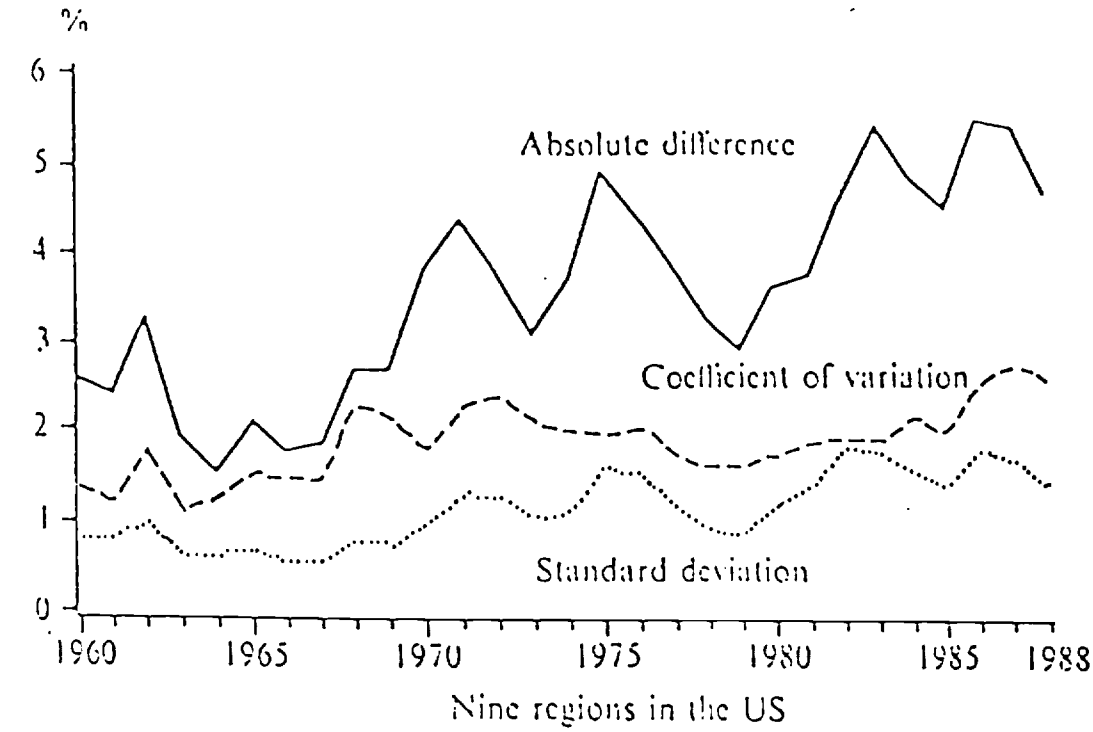


Source: same as Figure 1.

Figure 3
Mean Levels of Total External and Concessional Debt as % of GNP



Source: World Bank CD-ROM.



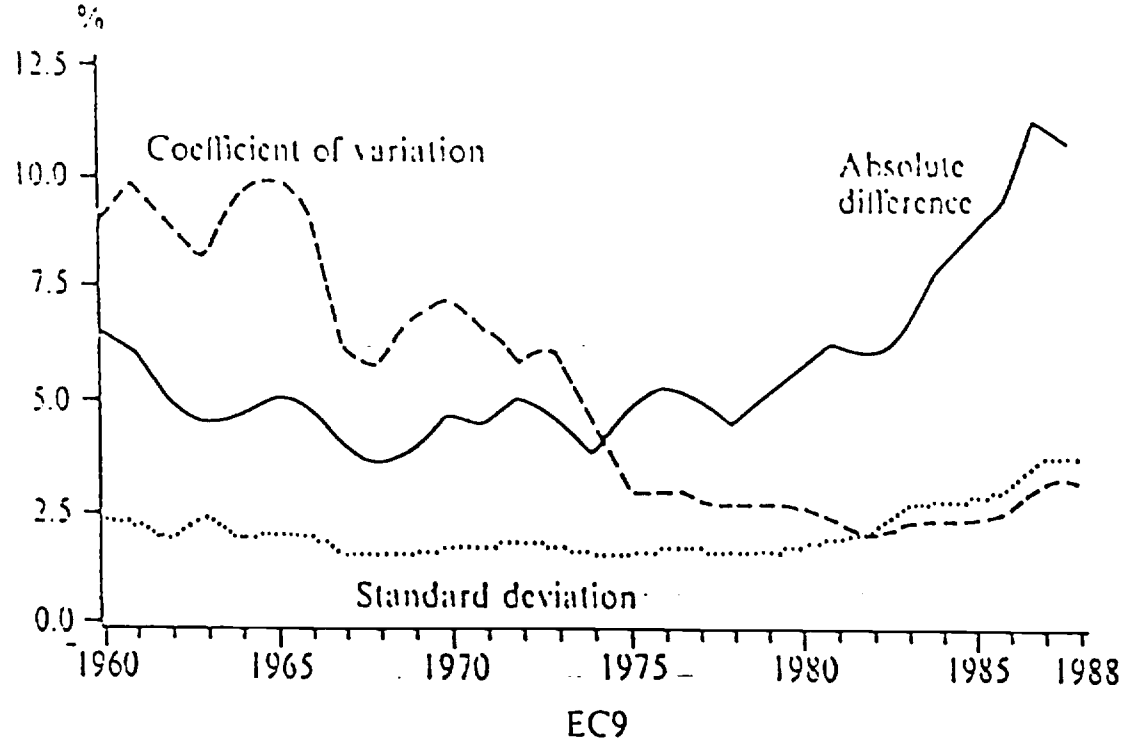


Figure 4. Dispersion of unemployment rates
Source: Eichengreen (1990)