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Accounting for the Stock of Human Capital: Selected Evidence and Potential Implications

By

Erich Gundlach

Contents: I. Introduction. – II. A Conceptional Framework for Measuring the Stock of Human Capital. – III. Estimating the Relative Stock of Human Capital. – IV. The Stock of Human Capital and International Capital Flows. – V. Conclusions.

I. Introduction

International capital movements and trade flows mainly occur between the relatively rich nations of the world economy. This empirical pattern is just the opposite of what could be expected from a simple neoclassical model of trade and growth. With labor and capital as the basic factors of production, and an internationally available technology with constant returns to scale, such a model implies that internationally different per capita incomes or per worker production levels must be due to internationally different levels of (physical) capital per worker. With a higher marginal product of capital in the relatively poor countries, it follows that capital should flow from rich to poor countries. The model predicts that this process will continue until the returns to the factors of production will be equalized. Hence, profits and wages are supposed to converge in the long run.

The standard explanation why the expected capital flows and an overall quasi-automatic convergence of per capita incomes are not observed is the absence of market economies and an appropriate institutional framework, and especially the absence of assured property rights or the existence of political risks in many developing countries. Apart from the empirical problem of how to measure the impact of these factors, some doubts remain whether this argument provides a sufficient explanation. First, even among developed market econo-

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mies with a comparable institutional framework and assured property rights, the extent of real capital mobility is surprisingly low, as was first shown by Feldstein and Horioka [1980]. Although their results have been criticized for various reasons,[1] the core of their argument is still valid: Since national saving and investment rates are highly correlated, real capital is not as mobile between countries as observed financial capital flows seem to suggest. Second, prior to 1945, much of the Third World had been subject to legal and institutional arrangements imposed by the colonial powers for decades, and in some cases even for more than a century. No major real capital flows in favor of the colonies occurred, however, despite the obvious absence of a political risk. According to Davis and Huttenback [1989], the reason was that rates of return on capital in, e.g., the British colonies did not exceed European returns for similar investments. Hence the question arises why rates of return on capital can be equalized between countries with similar institutional frameworks in the face of substantial differences in per capita incomes.

This paper discusses the hypothesis that part of the explanation why the expected capital flows are not observed may be the existence of external benefits of human capital [Lucas, 1988; 1990]. This hypothesis can change the direction of the predicted capital flows, because it may imply that human capital and not physical capital is the relatively scarce factor in developing countries. That is, the implicit rate of return differentials may vanish if international differences in the stock of human capital and possibly existing human capital externalities are properly accounted for.

Apart from the externality question it seems to be almost self-evident that international differences in the stock of human capital are somehow positively related to the observed income differentials between the industrialized and the developing countries. Recent attempts to incorporate human capital variables into the analysis of cross-country growth equations have shown that the hypothesis of long-run (conditional) convergence as derived from a constant returns to scale growth model can not be ruled out [Barro, 1991; Levine and Renelt, 1992; Mankiw et al., 1992]. However, it is rather doubtful whether these results rule out the alternative hypothesis of external benefits of human capital, since the speed of (conditional) convergence seems to be rather slow: It is estimated that the halfway time to

[1] For a recent review, see Frankel [1992].

reach a steady state after an exogenous shock is about 35 years.[2] Therefore, if shocks occur frequently enough the concept of catching up and convergence somehow loses its empirical relevance. Empirical support for the hypothesis of a rather limited potential for catching up in terms of per capita incomes comes from Quah [1993]. Allowing for stochastically time-varying components in the underlying data generating process, he finds that the economies across the world seem to be converging to a distribution where many remain wealthy, and many remain poor, and middle-income countries seem to be a vanishing class. This conclusion introduces the question whether economic policies with respect to human capital formation could change the speed of catching up.

Up to now, the measurement of human capital in a cross-country context rests on rather crude attempts to empirically identify this theoretical variable.[3] Mainly secondary school enrollment rates or literacy rates have been used as proxies for the investment in human capital or the stock of human capital. Recently, several authors have constructed somewhat improved estimates for the educational attainment of the labor force in a cross-country context, which may serve as a proxy for the stock of human capital. In a background study for the World Development Report 1991, Lau et al. [1991] provide panel estimates based on cumulated primary and secondary school enrollment rates and on assumptions about survival rates of the population. Psacharopoulos and Arriagada [1992] additionally include higher-level education but solely rely on census and survey data. Kyríacou [1991] also constructed panel data by using recent school enrollment rates to extrapolate previous Psacharopoulos-Arriagada data for the 1970s. At present, the most comprehensive approach is provided by Barro and Lee [1993], who use a large number of census and survey data, across countries and over time, and interpolation techniques to derive at a data set for the years of completed schooling for persons aged 25 and over, for 129 countries over five-year periods from 1960 to 1985. Still, all these measures ignore two important factors of human capital accumulation: the experience of the workforce, and

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[2] This speed of convergence has been estimated from various cross-section sources. For international output movements, see Mankiw et al. [1992]; for regional output movements across European economies, see Barro and Sala-i-Martin [1991]; for regional output movements across the United States, see Barro and Sala-i-Martin [1992].

[3] By contrast, see the pioneering work of Denison [1962] for estimating the contribution of improved labor quality (human capital accumulation) to income growth in a time-series context.

international differences in the quality of formal education. Therefore, it is tempting to conclude that all recent studies have used a proxy for human capital which is more or less uncorrelated with the "true" stock of human capital.

Without improved cross-country estimates of the stock of human capital it is rather difficult to evaluate the role of human capital formation for economic development, and even more so to evaluate the externality argument with respect to human capital. Both questions are rather crucial for economic policy considerations. For instance, if such externalities exist, there may be large macroeconomic benefits of economic policies promoting the education and training of the workforce. And even if such externalities do not exist, policies promoting education and training of the workforce may have a more beneficial impact on per capita incomes than policies enhancing the accumulation of physical capital.

Appropriate human capital stock series might be constructed by defining the human capital investment made during a year by the sum of the social per capita costs of education over all pupils and students [Schultz, 1993]. At least for most developing countries, however, even the necessary statistics on educational expenditures are not available; and even if they were, the human capital accumulated by experience would not be accounted for. In a seminal paper, Krueger [1968] developed an indirect way to estimate the *relative* stock of human capital from census data for a cross section of countries. In the next sections, I extend her approach and present estimates for the stock of human capital for selected countries relative to the United States in 1980. Employing alternative neoclassical growth models, I use these estimates to reconsider the predicted direction of international capital flows.

II. A Conceptional Framework for Measuring the Stock of Human Capital

Following closely the approach suggested by Krueger [1968, pp. 642–645], I assume that all countries have access to the same technology. This common technology may be represented by an aggregate constant returns to scale production function of the general form:

$$Y = f(X_0, X_1, \ldots, X_i, \ldots, X_n), \tag{1}$$

where Y is total income, and the X_i's are the quantities of the factors of production; let X_0 be the number of persons in the labor force. The marginal products of all factors are assumed to be positive and diminishing, and are denoted by f_i':

$$Y = f_0' X_0 + \ldots + f_i' X_i + \ldots + f_n' X_n . \tag{2}$$

Using this framework, consider the case of a resource-rich and resource-poor country. With small letters indicating per capita variables, let

$$y^p = \sum_i f_{i_h}'^p h_i^p + \sum_j f_{j_z}'^p z_j^p \tag{3}$$

describe the production function for the resource-poor country, and let

$$y^r = \sum_i f_{i_h}'^r h_i^r + \sum_j f_{j_z}'^r z_j^r \tag{4}$$

describe the production function for the resource-rich country, where the h_i's are quantities of specific elements of the stock of human capital, and the z_j's are the quantities of all other production factors (both on a per capita basis). Assume further that the rich country has more resources of every factor on a per capita basis than the poor country, and that only certain elements of the stock of human capital such as age and education can be observed. In such a setting, it follows that the maximum relative income the average person from a poor country can achieve if he were working with otherwise identical factor endowments of the rich country is given by

$$\tilde{y}^p_{\max} = \sum_i f_{i_h}'^r h_i^p / \sum_i f_{i_h}'^r h_i^r , \tag{5}$$

where the human capital resources of the poor country are evaluated with the marginal products of the rich country, which also reflect the endowment with all other factors of production.

Given the above assumptions, this relative income is larger than the actually observed income differential, because only different stocks of human capital are considered and all other factor deficiencies of the resource-poor country are ignored. To see why this is so, first consider the case that both countries have identical factor endowments. Thus no income differential should exist. Second, assume that the poor and the rich country have the same endowment of every factor except for human capital, of which the poor country has less. Hence, the actual income differential should reflect the different endowments with human capital. Third, assume that the poor country has less of every factor of production, but only human capital endowments can be ob-

served. Then (5) gives the *maximum* relative income attainable for the average person from the poor country, because all other endowment deficiencies of the poor country are ignored, although they may also contribute to the observed income differential.

Put differently, the use of the marginal products of the rich country will understate the "true" difference in income resulting from the resource disparity, since these marginal products depend on the endowment with all other factors of production which are assumed to be more abundant in the rich country than in the poor country. If certain quantities of specific elements of the stock of human capital are known for both countries, the marginal product of this factor in the rich country can be used to compute a lower-bound estimate of the resulting difference in per capita incomes. Furthermore, something can be said about the relative importance of factor endowments for which no information is available. If a fraction of the observed income differential between the poor and the rich country is known to be due to a deficiency of a subset of m resources, then all other factors cannot account for more than $y^r - y^p - y_m$, where y_m is the fraction of the income differential due to the identified resource differences. This calculation, which was the main issue addressed by Krueger [1968], may shed some light on the quantitative importance of different bottlenecks for economic development.

The estimates derived from (5) can be used to compute the stock of human capital in a poor country relative to a rich country, which is the main issue of this paper. Suppose that both countries are subject to a Cobb-Douglas per capita production function:

$$y^p = h_p^\beta z^\alpha \tag{6}$$

$$y^r = h_r^\beta z^\alpha , \tag{7}$$

where h represents the stock of human capital (labor), z represents all other resources and is assumed to be identical across countries, and α and β are the distributional shares of the inputs.

It follows that the relative per capita income is given by

$$\tilde{y}^p_{\max} = y^p / y^r = \tilde{h}^\beta . \tag{8}$$

If it is possible empirically to construct an index number from (5) which, given (8), has the dimension of the human capital stock raised to the power of labor's share, the relative stock of human capital in the poor country is given by:

$$\tilde{h} = e^{(\ln \tilde{y}^p_{\max})/\beta} . \tag{9}$$

The inverse of (9) gives the labor efficiency equivalent of an average worker from the rich country, with the dimension: number of average workers from the poor country per average worker from the rich country. That is, this figure gives the number of average workers from the poor country equivalent to the productivity of one average worker from the rich country, given that all workers are equipped with identical factor endowments except for human capital.

III. Estimating the Relative Stock of Human Capital

Estimating the relative stock of human capital by (9) requires the identification of resource endowments which are related to the theoretical concept of human capital, and the measurement of the respective marginal products in the country of reference. Following the seminal work of Becker [1964] and Mincer [1974], the major determinants of individual human capital accumulation are the years of formal schooling received, and the experience gained by learning on the job, typically measured by age. These factors have been found to explain a large fraction of observed income differentials between individuals.

Therefore, the analysis starts with a cross classification of the population by years of schooling completed and age, which is available from aggregated United States Census data for 1980 [US Department of Commerce, 1984]. Average United States incomes, disaggregated by years of formal schooling completed and by specific age groups, are used as the marginal products f_i' of the reference country (equation (5)). Choosing the United States to be the reference country is easily justified with respect to per capita income differentials, at least for the year 1980. The implication for the present analysis is that the United States is assumed to have more resources of every factor of production on a per capita basis than any other country in the sample.[4]

Other factors that might influence the measured efficiency of a unit of labor, especially when comparing the stock of human capital in the United States with the one in developing countries, are the degree of urbanization and the labor force participation rate of women. Since

[4] This assumption may be regarded as unreasonable with respect to unskilled and semi-skilled labor. However, on average a high-skilled worker can always do the work of a low-skilled worker. Hence, countries with more human capital per worker have as much unskilled labor as, and more skilled labor per capita than, countries with less human capital [Krueger, 1968].

average urban incomes are higher than rural incomes, and average female incomes are lower than male incomes, human capital endowments of developing countries estimated by the framework of the previous section will be biased upward in the case of less urbanization than in the reference country, and biased downward in the case of a lower female labor force participation. Therefore, I further extend the cross classification, namely by sex and place of residence.[5]

The most recent aggregated census data for a cross section of countries which allow for a cross classification by years of schooling, age, sex, and place of residence are available from the United Nations (UN) Demographic Yearbook [1985; 1990]. The list of countries for which this cross classification is possible is rather short, even if less important statistical problems are ignored. Countries included are: Bangladesh, Brazil, Cameroon, Canada, Ecuador, Honduras, Japan, New Zealand, Panama, and Sri Lanka. To match these data with the United States Census data, two major difficulties have to be considered.

First, the aggregated US data exclude all individuals younger than 18 years, whereas the UN data exclude all individuals younger than 15 years. In the computations below, I compare the US age cohort 18–24 to the age cohort 15–24 for the other countries in the sample. Since this age cohort accounts for a larger fraction of the population in developing countries, multiplication with the lower than average US marginal products will end up in a downward biased estimate of their relative human capital endowment.

Second, for most countries the UN data do not provide information on the years of schooling completed, but only on the *level* of schooling received. Here the main problem arises from differences in the average years of schooling by level: According to the UN data, first and secondary level each consist of six years of schooling, while in the United States the elementary (first) level consists of eight years, and high school (secondary level) consists of four years. To best match the UN classification with the published US Census classification, I compare 0–7 years of schooling in the United States to first level schooling in the other countries of the sample. This procedure may cause a small upward bias in the estimation of the relative human capital endowments, because the marginal product used is possibly higher than the

[5] The data for urban residence are not published in US Department of Commerce [1984] but can be computed as the weighted difference of the entries for "Total" and "Rural".

true marginal product for 0–6 years of formal schooling. A more severe upward bias may be introduced as drop-out rates can be expected to be much higher in developing countries than in the US. These effects are not controlled for in the UN data, i.e., the average person from a poor country reported to have been to primary education in a census actually may have received less than six years of formal education.

Table 1 presents the incomes (marginal products) assigned to individual classes on the basis of US Census data, aggregated to match the structure of the UN data. The marginal products for the United States (f_j') are derived by summing over individual census classes:

$$f_j' = \sum_i N_{ij} f_{ij}' / \sum_i P_{ij}\,, \tag{10}$$

where N_{ij} is the number of persons with income in ith subclass of j in the United States distribution, f_{ij}' is mean weakly earnings of those persons with income in the subclass, and P_{ij} is the total number of persons in the subclass. Multiplication of the f_j's with the respective fractions of the population, and summing up over the j subclasses, gives a human capital index number for the reference country. The human capital index for the country of comparison is derived in the same way by using its own population distribution (see (5)). Then, the estimation of the relative stock of human capital follows from (6) using additional information for the labor share (β) of the country of comparison.

By this computation, those persons with no earnings are assigned mean weakly earnings of zero. This is equivalent to allowing for subclass-specific labor force participation rates. Hence, it is assumed that United States' subclass-specific labor force participation rates resemble the labor force participation rates in the other countries of the sample. Compared to the difficulties that arise in matching the different distributions with respect to age cohorts and level of schooling, this assumption introduces more severe problems.

Since experience gained by learning on the job is one of the major determinants of human capital accumulation, internationally different labor force participation or unemployment rates will create biased estimates of human capital endowments in the present context, because countries with lower labor force participation rates and higher unemployment rates have to face higher depreciation rates of their stock of human capital. If the marginal products derived for the United States labor market experience are applied to a country with weaker labor market conditions, its estimated relative human capital

Table 1 – *Mean Weekly Earnings in 1979 by Age and Education for the United States, 1980 (US$)*

Age	Education[a]		
	first level	second level	third level
		1. Urban males	
18–24	112	159	174
25–34	173	271	343
35–44	213	340	529
45–54	222	348	585
55–64	173	288	518
65+	34	72	204
		2. Urban females	
18–24	57	99	128
25–34	68	120	191
35–44	73	122	196
45–54	66	115	195
55–64	47	88	162
65+	8	18	41
		3. Rural males	
18–24	103	167	187
25–34	162	278	337
35–44	203	335	477
45–54	201	326	508
55–64	152	256	421
65+	43	80	159
		4. Rural females	
18–24	43	87	121
25–34	54	95	157
35–44	56	101	163
45–54	53	93	167
55–64	37	67	131
65+	11	20	44

[a] First level = 0–7 years of schooling; second level = 8–12 years of schooling; third level = 12+ years of schooling.

Source: US Department of Commerce [1984, Table 295, pp. 447–450 and pp. 471–474].

endowment will be biased upward. Therefore, the present framework will produce reasonable results only if it is applied to countries with roughly comparable labor market experiences. In the absence of reliable labor market statistics for most of the developing countries in the sample, I use the growth rate of per capita income to proxy different

Table 2 – *Per Capita Growth Rates and Total Expenditures per Pupil for Selected Countries*

	Average annual growth rate of real per capita income, 1950–1980 (percent)[a] (1)	Total expenditures per pupil, 1980 (international US $)[b] (2)
United States	1.9	3,447
Bangladesh	0.4[c]	63
Brazil	5.0	551
Cameroon	3.6[d]	187
Canada	2.3	3,530
Ecuador	3.4	469
Honduras	1.6	171
Japan	6.7	2,178
New Zealand	1.6	1,657
Panama	3.4	480
Sri Lanka	0.9	175

[a] Computed from Summers and Heston [1991, column 2; $(\ln RGDPCH_t / \ln RDGPCH_0)/t$]. – [b] Computed from UNESCO [1988, Tables 3.4, 3.5, 3.7 and 4.1] and Summers and Heston [1991, columns 13 and 17] according to $(Exp/pup) \cdot PPP$, where *Exp/pup*: total expenditure per pupil; *P*: price level of GDP; *ExR*: exchange rate; *PPP*: purchasing power parity (GDP)$= P \cdot ExR$. – [c] 1959–1980. – [d] 1960–1980.

depreciation rates of the stock of human capital thereby assuming that faster economic growth goes hand in hand with more favorable labor market conditions. With the US rate as a point of reference, the least comparable countries seem to be Bangladesh and Sri Lanka (Table 2).

By the same token, the years of formal schooling received will only represent a comparable fraction of the human capital accumulated if the quality of schooling does not differ internationally. Up to now, there is only very limited empirical evidence on international differences in the quality of formal schooling.[6] Here, I use total public expenditures per pupil in 1980 as an extremely broad indicator of the quality of education. These data are available from the UNESCO Yearbook [1988]. To make them comparable internationally, expenditures are converted to international US $ by use of Purchasing Power

[6] For an analysis of the relative efficiency of private and public schools for selected developing countries, see Jimenez et al. [1991]; for an analysis of the consequences of different education policy regimes in Tanzania and Kenya, see Knight and Sabot [1990]; for a comparison of Asian and US schools based on achievement tests, see Stevenson [1992].

Parities provided by Summers and Heston [1991]. Again, Bangladesh and Sri Lanka are among the seemingly least comparable countries, but the large variation in cross-country expenditures per pupil should be also kept in mind for all other developing countries included in the sample.[7] Given that the estimates for the growth rate of per capita income and the expenditures per pupil in Table 2 are reasonable proxies for the depreciation rate of the stock of human capital and the quality of schooling, the countries most likely to offer comparable estimates for the stock of human capital are Cameroon, Canada, Brazil, Ecuador, Japan, and Panama. Estimates for the other countries will also be presented, but are considered to be less reliable.

Apart from international differences in the quality of education and in the rate of depreciation of human capital, the estimates may also be biased because of the level of aggregation used. For instance, if the fraction of those who actually *complete* first, second, or third level education differs internationally, human capital index numbers based on aggregated census data are not comparable as was argued above. This information is not available from the UN [1985; 1990] data for most of the countries in the sample; and from US Department of Commerce [1984], the highest disaggregation available by years of schooling completed is for eight subgroups which reflect the organization of the US educational system: 0–7 years and 8 years for the first level (elementary); 1–3 years and 4 years for the second level (high school); 1–3 years, 4 years, 5–6 years, and 7 or more years for the third level (college).

The robustness of the human capital estimate with respect to the level of aggregation is checked for the case of Panama by using microdata from the Socioeconomic Survey of 1983 [Republica de Panama, 1983][8] which includes information on the years of schooling completed. Since the distribution of the population generally changes very slowly, the discrepancy between the 1980 census data and the 1983 survey data can be neglected. The procedure used to calculate the alternative human capital index for Panama is the same as outlined above, the only difference being the level of aggregation of the years

[7] Psacharopoulos [1984] reports that public expenditures per pupil dramatically declined in developing countries between 1960 and 1975. He notes that according to unpublished estimates, the average OECD country invested fifty times more per pupil than did any low-income country in 1977, which is roughly in line with the estimates in Table 2; in 1960, this ratio stood at 16:1.

[8] A detailed description of the Socioeconomic Survey of Panama (SESP) conducted in 1983 is given in Sahota [1990].

Table 3 – *Relative Per Capita Incomes and Relative Human Capital Stocks, 1980*

	Relative per capita income[a] (percent) (1)[b]	Maximum attainable relative per capita income[a] (percent) (2)[c]	Percentage income differential explained by different human capital endowments (percent) (3)[d]	Labor share (4)[e]	Relative stock of human capital per person[a] (percent) (5)[f]	Labor efficiency equivalent per average person from the United States (6)[g]
Bangladesh	4.4	56.8	45.2	n.a.[h]	15.2	6.6
Brazil	29.7	61.5	55.0	n.a.[i]	37.8	2.6
Cameroon	10.1	55.4	49.6	0.36	19.4	5.2
Canada	92.9	94.0	85.7	0.69	91.4	1.1
Ecuador	21.7	60.5	50.6	0.39	27.6	3.6
Honduras	9.7	55.4	49.4	n.a.[j]	22.8	4.4
Japan	63.8	88.3	32.5	0.64	82.3	1.2
New Zealand	61.0	97.7	5.9	0.70	96.7	1.0
Panama	23.3	71.1	37.5	0.56	54.4	1.9
Panama (SESP)	–	73.9	33.9	–	58.3	1.7
Sri Lanka	10.8	61.2	43.5	0.59	43.5	2.3

[a] USA = 100. – [b] Summers and Heston [1991, column 8; *y*]. – [c] Computed according to $(\sum f_i'^r x_i^p / \sum f_i'^r x_i^r) \cdot 100$. Sources are United Nations [1985, Table 38 (x^p)]; United Nations [1990, Table 34 (x^p)]; Republica de Panama [1983] for Panama SESP (x^p); US Department of Commerce [1984, Table 296, pp. 447–450 and pp. 471–474] for x^r, f'^r. Dates of Census are: Bangladesh 1981, Brazil 1980, Cameroon 1976, Canada 1986, Ecuador 1974, Honduras 1983, Japan 1980, New Zealand 1981, Panama 1980, Sri Lanka 1981. – [d] Computed from columns (1) and (2) according to $[100-(2)]/[100-(1)] \cdot 100$. – [e] Computed according to $\beta = W/(GDP - T - D + S)$ where β: labor share, *GDP*: gross domestic product, *W*: compensation of employees, *T*: indirect taxes, *S*: subsidies, *D*: depreciation (approximated to be 10 percent). Source is United Nations [1989, Table 6]. – [f] Computed from columns (2) and (4) according to $e^{\ln[(2)/100]/(4)}$. – [g] Computed from column (5) according to [1/(5)]. – [h] Approximated to be 0.3 – [i] Approximated to be 0.5. – [j] Approximated to be 0.4.

of schooling. Here, I try to match the structure provided by the eight subgroups available for the United States. That is, if there are substantial differences of the population distributions *within* first, second, and third level education, then the two human capital stock estimates for Panama should differ.

Table 3 presents the results of the computations of the two central equations of the previous section: an estimate for the maximum income that an average person from a specific country could attain if he were working with United States factor endowments other than human capital (column (2), based on equation (5)); and, based on this finding, an estimate for the relative stock of human capital for a cross-section of countries (column (5), based on equation (9)). These results indicate that a substantial fraction of the observed per capita income differentials relative to the Untied States can be accounted for by differences in human capital endowments, thus replicating the basic finding in Krueger [1968]. The second entry for Panama shows that the estimates (for Panama) are largely uneffected by the level of aggregation of years of formal schooling received. The finding points to roughly similar cross-country population distributions *within* levels of education, at least in the case of the United States and Panama.

To be more specific, the results in Table 3 can be read as follows. In 1980, the income of the average Brazilian stood at roughly 30 percent of the income of the average person from the United States (column (1)). If the average Brazilian were working with United States factor endowments, he would double his income, reaching approximately 60 percent of the American level. Hence, his human capital endowment would not suffice to reach the average United States income level even if there were no other endowment deficiencies involved, which is why column (2) provides the *maximum* income attainable. Put differently, more than half of the observed income differential between the United States and Brazil is due to the lower Brazilian stock of human capital (column (3)), leaving less than half of the observed income differential to be due to other (unidentified) Brazilian resource deficiencies.

For Bangladesh, Cameroon, Ecuador, Honduras, and Sri Lanka the explanatory power of different human capital endowments for observed income differentials is of the same order of magnitude. In the case of Canada, almost all of the observed income differentials can be explained in terms of different human capital endowments. This result points to relatively identical overall factor endowments for Canada and the United States: if two countries exhibit the same set of factor

endowments except for human capital, the observed income differential should reflect the different human capital endowments. Contrary to these cases, the empirical evidence for Japan, Panama, and New Zealand suggests that different human capital endowments are less important for an explanation of the observed income differentials than other unidentified factor endowment deficiencies. Put differently, these countries seem to display relatively low per capita incomes despite a well-trained labor force. Such a finding may indicate the potential for fast future income growth, since it points to an unexploited resource endowment. Of course, this is not to say that unexploited resource endowments are a sufficient condition for prospective income growth, as both New Zealand and Panama prove.

The estimates for the relative stock of human capital resemble these considerations (column (5), based on equation (9)). For instance, the average person from Cameroon or Bangladesh has less than 20 percent of the human capital of the average American; average persons from Brazil have twice as much human capital as the former; and average persons from other OECD countries have almost as much human capital as the average American. Turning to labor efficiency equivalents (column (6)), these results reveal that international productivity assessments based on per capita (or per worker) incomes may lead to unduly pessimistic conclusions. While per capita income differentials imply that the average American is, say, as productive as 10 Cameroonians or 4 Panamanians (column (1)), the consideration of different human capital endowments reduces such estimates to a factor of 5 in the case of Cameroon and to a factor of 2 in the case of Panama.

Table 4 compares the estimates for the stock of human capital with recently published estimates based on alternative approaches. The estimates derived in this paper substantially differ from the estimates presented by Kyriacou [1991] and Lau et al. [1991], both with respect to level and variance across countries. They are more similar to the estimates presented by Barro and Lee [1993] and Psacharopoulos and Arriagada [1992]. Some striking differences remain, however. This paper comes up with a much lower estimate for Ecuador, and a higher estimate for Japan; in the case of Brazil, the estimate is between the estimates of the other two approaches.

Taken together, the large variation of the cross-section estimates for the relative stock of human capital may point to a high explanatory power of this concept with respect to different per capita incomes. Needless to say that all the estimates should be interpreted very care-

Table 4 – *Comparing Alternative Proxies for the Stock of Human Capital, ca. 1980*[a]

	Barro, Lee [1993][b]	Kyriacou [1991][c]	Lau et al. [1991][d]	Psacharopoulos, Arriagada [1992][e]	This paper[f]
Bangladesh	14.3	26.3	37.4	19.0	15.2
Brazil	25.1	45.5	32.4	44.4	37.8
Cameroon	15.1	40.0	29.8	17.5	19.4
Canada	85.4	79.9	n.a.	92.9	91.4
Ecuador	45.4	57.5	n.a.	51.6	27.6
Honduras	22.7	38.2	n.a.	27.8	22.8
Japan	68.9	74.0	76.0	77.8	82.3
New Zealand	104.5	73.1	n.a.	92.3	96.7
Panama	50.3	57.9	55.2	52.4	54.4
Sri Lanka	43.6	48.9	71.1	59.5	43.5
Note: Coefficient of variation	0.64	0.32	0.40	0.52	0.63

[a] Percent; USA = 100. – [b] Years of completed schooling for persons aged 25 and over. – [c] Estimated years of schooling in the labor force. – [d] Estimated average years of education of the population of working age group (15 to 64); the data are available from the World Bank on request; assumed absolute figure for the US: 12.2 years. – [e] Mean years of schooling embodied in the labor force. – [f] See Table 3.

fully, since they may suffer from a number of measurement and comparability problems some of which were outlined above. Compared to the presently available proxies for the stock of human capital referred to in Table 4, however, the estimates presented in this paper provide more comprehensive information. Most importantly, they include a measure of human capital accumulated by experience (proxied by the age structure of the population), and they additionally include third level education as well as adjustments for cross-country differences in the degree of urbanization and gender-specific age-education distributions.

IV. The Stock of Human Capital and International Capital Flows

Large differences in per capita incomes across the world can be interpreted as indicating a high marginal productivity of physical capital in poor countries, implicitly predicting large international capital flows. Actually, this does not happen. The relative stocks of human capital estimated in this paper can be used to give an explanation of this puzzle in terms of a quantitative assessment.

Following Lucas [1990][9], I reproduce the performance of three simple neoclassical models in predicting the direction of international capital flows between the United States, as the country of reference, and the stylized economies of "South Asia", "Latin America", and "Other OECD" which consist of the population weighted averages of Bangladesh and Sri Lanka; Brazil, Ecuador, Honduras, and Panama; and Canada, Japan, and New Zealand, respectively. Acknowledging the numerous difficulties involved in the estimation procedure outlined in the previous section, it is nonetheless hoped that these broad averages may serve as proxies for interregional differences in the stock of human capital which allow an assessment of predictions derived from alternative growth models.

Consider a Cobb-Douglas constant returns technology with a common intercept and assume that this technology is available for all countries:

$$Y = A K^{\alpha} L^{1-\alpha}, \tag{11}$$

where Y is total income, K is physical capital, and L is labor. Per capita income is given by:

$$y = A k^{\alpha}, \tag{12}$$

where y and k are income and physical capital, both per capita. The marginal product of capital (r) is given by:

$$r = \partial y / \partial k = A \alpha k^{\alpha - 1}. \tag{13}$$

Using the inverse of the production function, the marginal product of capital in terms of per capita income is given by:

$$r = A^{1/\alpha} \alpha y^{(\alpha - 1)/\alpha}. \tag{14}$$

Hence, for average capital shares ($\bar{\alpha}$), and y measured relative to the United States, equation (14) implies that the rate of return to capital in any country is $y^{(\bar{\alpha}-1)/\bar{\alpha}}$ times higher than in the United States. Hence, this model predicts that the rate of return to capital in South Asia is 89 times, in Latin America 6 times, and in other OECD more than 2 times higher than in the United States (Table 5, Model 1).[10]

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[9] Lucas [1990] found that external benefits of human capital could account for a near equivalence of the rates of return to physical capital between the United States and India, thereby explaining the apparent lack of net international capital flows to the latter.

[10] Applying these calculations to the data for Canada from Table 3 produces a factor of 1, i.e., factor price equalization between Canada and the US.

Table 5 – *Predicted Rate of Return Differentials Relative to the United States (Factor of proportionality)* [a]

	Relative per capita income [b] (y)	Relative per capita stock of human capital [b] (h)	Average profit share ($\bar{\alpha}$)	Rate of return in ... is ... times higher than in the United States			
				Model 1	Model 2	Model 3	
						$\gamma=0.4$	$\gamma=1.4$
South Asia [c]	0.05	0.20	0.4	89.4	8	1.6	0.005
Latin America [d]	0.30	0.40	0.4	6.1	1.5	0.6	0.06
Other OECD [e]	0.70	0.85	0.3	2.3	1.6	1.3	0.75

[a] All columns (computed) from Table 3. $\alpha_i=1-\beta_i$; $\alpha_{US}=0.25$; $\bar{\alpha}\approx\frac{1}{2}\sum_i\alpha_i+\frac{1}{2}\alpha_{US}$. Model 1: $y^{(\bar{\alpha}-1)/\bar{\alpha}}$; model 2: $(y/h)^{(\bar{\alpha}-1)/\bar{\alpha}}$; model 3: $(y/h)^{(\bar{\alpha}-1)/\bar{\alpha}}h^{\gamma/\bar{\alpha}}$. – [b] Approximated population weighted averages. – [c] Bangladesh, Sri Lanka. – [d] Brazil, Ecuador, Honduras, Panama. – [e] Canada, Japan, New Zealand.

An apparent reason why these large rate of return differentials are exaggerated is the use of the per capita concept, which assumes persons in the United States and elsewhere as having the same productivity. Considering international differences in the stock of human capital, the production function reads:

$$Y = AK^{\alpha}(hL)^{1-\alpha}, \tag{15}$$

where h is the stock of human capital per person. Income per *effective* person (y_e) is given by:

$$y_e = Ak_e^{\alpha} \quad \text{with} \quad y_e = Y/hL \quad \text{and} \quad k_e = K/hL. \tag{16}$$

Similar to (14), the marginal product of capital in terms of income per effective person is given by:

$$r = A^{1/\alpha}\alpha(y/h)^{(\alpha-1)/\alpha}. \tag{17}$$

Following this model, the previously estimated rate of return differentials (from (14)) are sharply reduced (Table 5, Model 2). Rate of return differentials in the range of 50 percent with respect to Latin America may not be high enough to offset the risks of investing there, but should provide a strong motive to transfer capital from the US to other OECD countries. The largest differential remains in the case of South Asia: If the rate of return to capital in stylized South Asia really were 700 percent higher than in the United States as predicted by this model, one would expect to see a large amount of capital flowing from the US to this region. Instead, labor seems to flow at maximum allowable rates to the United States not only from South Asia, but also

from Latin America. If there is a strong motive for labor to flow in one direction, however, there should be an equally strong motive for capital to flow in the opposite direction. Why this does not happen can be explained by a model which includes an internal as well as an external effect related to the stock of human capital [Lucas, 1988]. In this model, the production function for income per effective person is given by:

$$y_e = A k_e^{\alpha} h^{\gamma} . \tag{18}$$

The term h^{γ} can be interpreted as an external effect which multiplies the productivity of a worker at any skill level. Hence (18) says that an increase in the average stock of human capital by 1 percent will increase the human capital of an individual working in this environment by γ percent. The implication is that this model can account for different cross-country incomes per effective person, even if the rates of return to physical capital are equalized, and the technology is generally available. In the previous models, rates of return to capital could not equalize as long as per capita incomes differed. Here, the remaining spread may just be offset or even turned around by the human capital externality. The corresponding equation for the marginal product of capital clarifies this interpretation:

$$r = A^{1/\alpha} \alpha y_e^{(\alpha-1)/\alpha} h^{\gamma/\alpha} . \tag{19}$$

This model requires an empirical estimate for γ. Lucas [1988, p. 22] shows how to derive such an estimate. First rewrite (18) in terms of *per capita* income:

$$y = A k^{\alpha} h^{(1-\alpha)} h^{\gamma} . \tag{20}$$

Then, the marginal product of capital equation reads:

$$r = A \alpha k^{(\alpha-1)} h^{(1-\alpha)} h^{\gamma} . \tag{21}$$

With the Cobb-Douglas technology used here, the marginal product of capital equals the profit share times the average product. Writing (21) in logs (ln) and using $r = \alpha(y/k)$ gives the steady state solution of the model for a common growth rate of per capita income ($\ln y$) and per capita capital ($\ln k$) as:

$$\ln y = [(1-\alpha+\gamma)/(1-\alpha)] \ln h . \tag{22}$$

At least for the United States, it is possible to estimate γ, given that the average annual growth rate of the stock of human capital ($\ln h$) can be proxied by an estimate based on the growth of formal schooling alone.

Lucas [1988; 1990] computed a value for γ of approximately 0.4 using estimates for $\ln y_{US}=0.014$, $\alpha_{US}=0.25$, and $\ln h_{US}=0.009$ from Denison [1962] for the period 1909–1957. Here, I compute an alternative estimate for γ of approximately 1.4 which is based on estimates for $\ln y_{US}=0.017$ derived from Maddison [1991] for the periods 1820–1989 and 1820–1973, and on estimates for $\ln h_{US}=0.006$ derived from Denison [1974; 1985] for the periods 1929–1969, 1947–1969, and 1929–1982, with $\alpha_{US}=0.25$ as before. Somewhat unrealistically, this estimate for γ implies that a doubling of all inputs would increase output by a factor of five. However, the results for γ are very sensitive with respect to the proxy for $\ln h$ and should only be taken as a range of possible outcomes. Notwithstanding, some conclusions with respect to rate of return differentials and the direction of international capital flows can be drawn.

Going back to (19), the rate of return differentials further decline if an externality ($\gamma=0.4$) is introduced. By and large, the results could be interpreted as representing rate of return equalization; the result for Latin America points to a somewhat lower rate of return than in the United States (Table 5, model 3). By giving a stronger weight to the human capital externality, the results become more diverse. Broadly speaking, for the extreme case of $\gamma=1.4$, the estimates are not too far away from rate of return equalization in the case of other OECD, but reveal rate of return differentials *in favor* of the United States by a factor of 200 in the case of South Asia and by a factor of 17 in the case of Latin America. Hence, one should not expect *any* investment in physical capital occurring in these regions. Actually, these regions not only experienced positive investment rates, but also attracted some capital inflows,[11] at least until the early eighthies. Therefore, obviously, an estimate for γ closer to 0.4 than to 1.4 seems to be more reasonable.

These back-of-the-envelope calculations reveal that accounting for human capital externalities may change the predicted direction of international capital flows, contrary to what may be indicated by per capita income differentials alone. The empirical plausibility of a human capital externality can be assessed by (22). The externality disappears ($\gamma=0$) if the growth rate of per capita income equals the growth rate of the per capita stock of human capital. Put differently, with relatively well documented estimates for the long-run growth rate

[11] Compare Summers and Heston [1991, columns 3, 4 and 5]: [100-c-i-g] gives a negative current account balance (percent of GDP), which indicates net capital inflows.

of the United States per capita income ($\ln y_{US} \approx 1.7$) and for the capital share ($\alpha_{US} \approx 0.25$), the Denison [1962; 1974; 1985] estimates for the long-run growth rate of the stock of human capital would have to be corrected by a factor of 2 or 3 to eliminate the externality effect.

Although the presented empirical evidence does not suffice to derive a conclusive point estimate of the human capital externality, it is somewhat difficult to deny its existence in the context of the underlying production function approach. The implication of this hypothesis is that the incentive for capital to flow to relatively poor countries is probably even much lower than indicated by human capital adjusted income differentials. As a consequence, the catching-up potential of relatively poor countries may be severely restricted by their ability to raise their stock of human capital. This interpretation, if supported by further empirical evidence, may lead to a reconsideration of the relative importance of development policies encouraging the accumulation of human capital.

V. Conclusions

Despite the unequal distribution of incomes in the world economy, relatively little capital is flowing to poor countries. A fair description of tendencies prevailing since World War II seems to be that the world economy is converging to a distribution of incomes where many countries remain wealthy, and many remain poor [Quah, 1993]. One way to explain this empirical pattern is to stress "political risk" as the decisive factor limiting international capital flows to poor countries. Following this interpretation, international factor (for that matter, capital) mobility could induce a catching up of the have-nots, and finally a convergence of per capita incomes, if only political risks were eliminated.

Recently, advances in growth theory have led to endogenous growth models that are capable of explaining persistent income differentials. The crucial feature of these models is a departure from the usual assumption of diminishing returns to the factors of production. As was first shown by Romer [1986], a competitive dynamic equilibrium can exist if overall increasing returns to scale are external to the firm. For the empirical analysis, the question remains where to look for an externality. While many models can replicate the empirical patterns, the Lucas [1988] model of a human capital externality provides a promising starting point, because it includes variables that can

be measured, at least in principle. Employing this model first of all requires cross-country information on the stock of human capital.

The estimates for the relative stock of human capital presented in Section III provide a first step in this direction. They are limited to a rather small sample of countries, and certainly suffer from a number of shortcomings which call for further research. Still, they are more comprehensive than other presently available estimates for the stock of human capital. Their empirical plausibility can be assessed within a production function framework. The results suggest that accounting for the *stock* of human capital somewhat reduces the implicit rate of return differentials based on different per capita incomes, thereby partly explaining why relatively little capital flows to poor countries.

In the presence of political risk, remaining rate of return differentials in favor of poor countries may not suffice to encourage substantial capital flows. This interpretation is compatible with the empirical facts, as well as an alternative interpretation, focussing on human capital externalities. Referring to independent empirical evidence for the United States, the existence of human capital externalities does not seem to be completely implausible. Given the estimates for the relative stock of human capital for the sample of countries used in this paper, accounting for human capital *externalities* reveals that rates of return to physical capital may be substantially higher in *rich* countries than in poor countries.

Without improved empirical evidence, it seems to be rather difficult to discriminate between the externality hypothesis and the political risk hypothesis. Both hypotheses may be relevant for an explanation of real-world phenomena. But if the rates of return to capital are actually higher in rich countries, net capital flows to poor countries will be fully offset by a reduction of domestic investment. Therefore, external and internal development policies should mainly focus on human capital accumulation, on investing in people rather than investing in physical capital. Obviously, this strategy will fail to induce a catching up of poor countries, if political risk is the decisive limiting factor of economic development. Still, even eliminating political risks will not suffice to induce a catching up as long as large cross-country differences in stocks of human capital exist in the presence of human capital externalities.

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* * *

Abstract: Accounting for the Stock of Human Capital: Selected Evidence and Potential Implications. – Given the observed distribution of output and labor across countries, most capital flows should be from rich to poor countries. As is shown for a limited sample of countries, accounting for differences in the stock of human capital

substantially reduces the implicit cross-country rate of return differentials. Additionally, accounting for human capital externalities based on independent empirical evidence, turns around the predicted rate of return differentials in favor of rich countries. Hence, the world economy may converge to a rather unequal distribution of incomes as long as human capital accumulation is neglected as the key variable limiting economic development. JEL No. F21, J24

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Zusammenfassung: Berücksichtigung des Humankapitalbestandes: Einige ausgewählte Befunde und mögliche Implikationen. – Angesichts der beobachteten Verteilung von Produktion und Arbeit zwischen den Ländern müßten die meisten Kapitalströme von den reichen zu den armen Ländern fließen. Der Autor zeigt für eine begrenzte Auswahl von Ländern, daß sich die impliziten Ertragsdifferenzen zwischen ihnen erheblich verringern, wenn Unterschiede im Humankapitalbestand berücksichtigt werden. Außerdem führt die Berücksichtigung der auf unabhängigen empirischen Studien beruhenden Externalitäten des Humankapitals dazu, daß sich die vorhergesagten Ertragsdifferenzen zugunsten der reichen Länder umkehren. Demgemäß kann es in der Weltwirtschaft zu einer ziemlich ungleichen Einkommensverteilung kommen, solange die Akkumulation von Humankapital als Schlüsselvariable für die wirtschaftliche Entwicklung vernachlässigt wird.