Education and Income Growth: Implications for Cross-Country Inequality

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This paper examines the extent to which patterns of human capital convergence can account for observed patterns of income inequality between countries. To do this I decompose national income into three components: one due to education levels, one reflecting the return to education, and a residual component. I then examine in turn the contribution of each of them to changes in income dispersion. Among the developed countries, convergence in education levels has resulted in a reduction in income dispersion. However, for the world as a whole, incomes have diverged despite substantial convergence in education levels. This is a result of increases in the return to education that favor the developed countries at the expense of the less developed countries.

I. Introduction

The issue of income inequality has been studied extensively in the recent literature on economic growth. A general consensus appears to have emerged that, at least for the developed economies, incomes of the poorest countries have tended to converge to those of the leaders (Abramovitz 1986; Baumol 1986). However, for the world as a whole, the trend is one of rising inequality as the developed countries move further ahead of the less developed countries (LDCs). This pattern of convergence is documented in table 1, which shows the

I would like to thank Joel Horowitz, John Kennan, George Neumann, Robert Tamura, an anonymous referee, and an editor for helpful comments and suggestions regarding this paper.

[*Journal of Political Economy*, 1995, vol. 103, no. 6]
 0022-3808/95/0306-0006$01.50

TABLE 1

VARIANCE OF LOG REAL GROSS DOMESTIC PRODUCT PER CAPITA, 1967 AND 1985

Sample	1967	1985
Developed countries	.356	.189
Europe	.255	.184
LDCs	.529	.677
World	.992	1.36

variance in the log of real gross domestic product per capita among developed countries, Europe, the LDCs, and the world as a whole.[1]

While these patterns of relative income growth are familiar to many, substantially less is known about what has caused these changes. In this paper, I examine two popular explanations of the convergence phenomenon. The first, based on the work of Solow (1956), predicts that income convergence should be preceded by convergence in physical capital, reflecting diminishing returns to investment in physical capital. The second, developed formally in Romer (1989) and Tamura (1991*b*), predicts that income convergence follows as a result of the flow of technology and human capital from the leading countries to the lagging countries. To quote Tamura, "Income convergence arises from human capital convergence. . . . Individuals with below-average human capital gain disproportionately by the external effect compared with above-average human capital agents. . . . Convergence arises because below-average human capital agents gain the most from learning" (pp. 522–23).

While earlier studies (Tilak 1989) suggest that increased education can substantially reduce inequality *within* countries, as yet no study has examined the role of education in determining income convergence *between* countries. In this paper, I focus on the extent to which convergence in education levels can explain the cross-country convergence patterns presented in table 1. The findings are based on a procedure that decomposes the variation in income over time into components resulting from changes in the distribution of characteristics across countries (a quantity effect), changes in the valuation of these characteristics (a price effect), and a residual component. Distinguishing between the impact of changes in "quantities" and "prices"

[1] The results on income convergence within the developed world have been challenged recently on the basis of selection bias (De Long 1988). However, work by Baumol, Blackman, and Wolff (1989) suggests that there remains significant convergence even when the samples are chosen on an ex ante basis. Furthermore, since this paper focuses on the failure of incomes to converge *at the world level*, despite substantial convergence in education levels, the issue of selection bias is not central to this study.

on the distribution of income allows one to isolate the impact of changes in the returns to education on income dispersion.

I find that changes in human capital levels provide a good predictor of the temporal pattern of income convergence among developed countries, with the decline in the rate of income convergence among European countries beginning in the mid 1970s being matched by a similar fall in the rate of education convergence. More important, I show that an analysis of the relationship between education and income can also help explain the poor performance of the LDCs relative to that of the developed countries. To do so, however, it is crucial that one examine not only movements in factor quantities but also movements in factor prices. Despite substantial improvements in education levels, the LDCs are still located in the lower tail of the education distribution. As a result, forces that tend to raise the return to education, such as an increased emphasis on skilled labor in the production process, favor the developed countries at the expense of the LDCs, leading to a divergence in income levels. Previous studies of convergence that have focused on changing characteristics have ignored the potential role of prices, thus providing only a partial explanation of income behavior.

II. Data

This study analyzes income convergence between 1967 and 1985. As a measure of output, I use the logarithm of real per capita GDP. This is taken from Summers and Heston (1988) and is measured in 1980 international prices. Gross secondary school enrollment ratios are used to measure a country's level of human capital. These figures were obtained from yearbooks of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) and measure the number of students of *all* ages enrolled in school as a percentage of the total population of schooling age.

In many of the earlier studies, current levels of education were related to current levels of income. However, under the hypothesis that changes in education *cause* changes in income, one would expect variation in education levels to precede changes in output. For this reason, I introduce a time lag on the measure of human capital throughout this study. To determine the appropriate lag length for a country, I use the duration of secondary schooling reported by UNESCO, lagging the schooling variable accordingly.[2] While bias may still remain in such a lagged specification, particularly if the

[2] The average duration of secondary school is 4.9 years for the developing countries and 5.2 years for the developed countries.

income variable is serially correlated, one would expect the correlation resulting from such bias to be highest at shorter lags of schooling. In contrast, I find that the lag lengths used in this study provide a much better fit to the data than shorter lags. Later in the paper I also report the results when average years of schooling is used as a measure of human capital. Using years of schooling has the advantage of measuring the stock of human capital in a country at a point in time. As is shown in the next section, the conclusions of this study are robust to the choice of education measure.

Since capital stock data are not available for the majority of the countries examined in this study, I use investment's share in GDP, taken from the Summers and Heston data, to proxy for the capital stock. Data on the labor force are taken from Summers and Heston (1991). The countries used are listed in table A1 of the Appendix and exclude both the OPEC countries and those countries for which the data were incomplete.

III. Education and Economic Growth: A Price-Quantity Based Distributional Analysis

Educational enrollment ratios increased dramatically throughout the world over the last two decades.[3] This education explosion combined with the inability of conventional factors, such as capital and labor, to explain economic growth patterns resulted in the emergence of a substantial literature examining the impact of education on economic growth.[4] Recent work on the relationship between education and income has focused directly on the role of education levels in determining income convergence across countries. This has generally involved estimation of a growth equation, in which a country's growth in per capita GDP is regressed on its initial GDP as well as its education level at some intermediate point.[5] The results of these studies show that controlling for initial human capital induces a substantial negative relationship between per capita growth and initial GDP *even at the world level.* However, when a country's growth rate in human capital is used to explain its growth in income, education appears to have an insignificant effect (Kyriacou 1991). While the LDCs have experi-

[3] Between 1960 and 1985, enrollment ratios increased at an average annual rate of 12 percent at the primary level, 37 percent at the secondary level, and 43 percent at higher levels for developing countries and −0.8 percent, 2.9 percent, and 9.6 percent, respectively, for the developed countries (Tilak 1989).

[4] For a detailed summary of much of this work, see Tilak (1989).

[5] See Levine and Renelt (1992) and Sala-i-Martin (1994) for a survey of this work and Friedman (1992) and Quah (1993) for a critique of the techniques used in such studies.

enced the fastest growth rates in human capital, in terms of income they have fallen further behind the developed countries.

In this paper, I examine one possible explanation for the failure of improved education levels among the LDCs to translate into improvements in relative income growth, namely the role of rising returns to factors of production resulting from technological change. To see the importance of factor price changes, consider the following log-linear production function in which the share parameters are allowed to vary over time:

$$\mathrm{GDP}_{it} = \alpha_{0t} + \alpha_{1t}H_{it} + \alpha_{2t}K_{it} + \alpha_{3t}L_{it} + u_{it}. \tag{1}$$

This production function expresses the log of per capita GDP of country i in year t (GDP_{it}) as a function of log human capital H_{it} (proxied by lagged school enrollment ratios), log physical capital K_{it} (proxied by lagged investment), the log of the labor force (L_{it}), and a random error term u_{it}. Writing the production function in level form rather than growth form, as in many previous studies, allows us to break up the time variation in cross-country income differences into three components: changes in the distribution of education, changes due to the value of education for given levels of education, and changes in the residual distribution (which in this case also includes changes in physical capital and the labor force). This decomposition can be expressed formally as

$$\begin{aligned}\mathrm{GDP}_{it} = {} & (\bar{\alpha}_0 + \bar{\alpha}_1 H_{it} + \bar{\alpha}_2 \bar{K} + \bar{\alpha}_3 \bar{L}) + H_{it}(\alpha_{1t} - \bar{\alpha}_1) \\ & + [u_{it} + (\alpha_{2t}K_{it} - \bar{\alpha}_2\bar{K}) + (\alpha_{3t}L_{it} - \bar{\alpha}_3\bar{L}) + (\alpha_{0t} - \bar{\alpha}_0)],\end{aligned} \tag{2}$$

where $\bar{\alpha}_j$ is the average of α_{jt} over t (1967–85) and $\bar{K}$ and $\bar{L}$ are K_{it} and L_{it}, respectively, averaged across countries over time. The first four terms in equation (2) capture the effect of changes in the education distribution over time, with education prices as well as the price and quantity of all other explanatory variables held fixed. The next term allows for changes in the price of education, and the remaining terms capture changes in the distribution of unobservables as well as changes in the levels and prices of the remaining explanatory variables.

Within this framework, one can analyze the behavior of the income distribution when various components are held fixed. For example, to estimate the impact of changes in education levels when the return to education as well as all other prices and quantities are held fixed, I estimate the following income series in which only education quantities are allowed to vary over time:[6]

[6] In order to calculate this income series, eq. (1) is estimated for each year. Then $\bar{\alpha}_k$, $k = 0, 1, 2, 3$, is calculated as the average of the estimated α_{kt} over time. The results

$$VQ_t = \text{var}_t(\bar{\alpha}_0 + \bar{\alpha}_1 H_{it} + \bar{\alpha}_2 \bar{K} + \bar{\alpha}_3 \bar{L}), \quad (3)$$

where var_t is the variance across countries at time t. To determine the impact of changes in education prices over time, I estimate

$$V_t^{++} = \text{var}_t(\bar{\alpha}_0 + \alpha_{1t} H_{it} + \bar{\alpha}_2 \bar{K} + \bar{\alpha}_3 \bar{L}). \quad (4)$$

In this case both the quantity and price of education are allowed to vary. The individual contribution of changes in the price of education over time is then estimated by

$$VP_t = V_t^{++} - VQ_t. \quad (5)$$

Finally, the impact of variation in other factors, along with unobserved variation, is estimated by

$$VR_t = Vinc_t - V_t^{++}, \quad (6)$$

where $Vinc_t$ is the variance in actual log income at time t.

The results of the decomposition are given in table 2. Column 1 presents the actual change in the variance of log income between 1967 and 1985. Columns 2, 3, and 4 present the contribution of each of the three components to the change in income dispersion over the 18-year period. Looking at the first two rows of table 2, which show the decomposition results for all the developed countries and for Europe separately, we see that in both cases, changes in education levels are an important determinant of changes in the distribution of income across countries. For both the developed countries and Europe, convergence in education levels has resulted in a significant reduction in income inequality. The pattern of convergence over time associated with education quantities is also striking. Figure 1 plots the variation in actual income among European countries along with the predicted income variation resulting from changes in education levels when prices are held fixed (VQ_t). Again we see that predicted income inequality falls as a result of convergence in education levels. However, we also see that the turning points in both series are similar with the slowdown in convergence beginning in the mid 1970s being matched by a similar slowdown in human capital convergence. The ability of education dispersion to trace out the dispersion of income, despite its nonlinear form, suggests that the relationship between income and education is causal rather than coincidental.

The results in table 2 also show that, for both the developed countries and Europe, the rise in the return to education experienced

presented in this paper are based on the assumption of regional prices for both physical and human capital. This is the preferred specification based on a Wald test for parameter stability across regions. However, the reported decomposition results are not sensitive to this assumption.

TABLE 2

INDIVIDUAL CONTRIBUTION OF EDUCATION QUANTITIES, EDUCATION PRICES, AND RESIDUALS TO CHANGES IN THE VARIANCE OF INCOME BETWEEN 1967 AND 1985

	Total Change in Income Variance (1)	Education Quantities (2)	Education Prices (3)	Residuals (4)	Ratio of Quantities to Prices* (5)
Developed countries	−.167	−.197	.159	−.13	1.24
Europe	−.071	−.123	.131	−.078	.94
LDCs	.148	−.192	.289	.05	.66
World	.365	−.237	.85	−.25	.28

NOTE.—Col. 1 shows the change in the variance of income over the sample period. Cols. 2–4 give the contribution of the individual components calculated using the decomposition technique outlined in the paper. The analysis covers the period 1967–85 because of the use of lagged schooling and investment variables.

* In all cases the negative sign has been omitted.

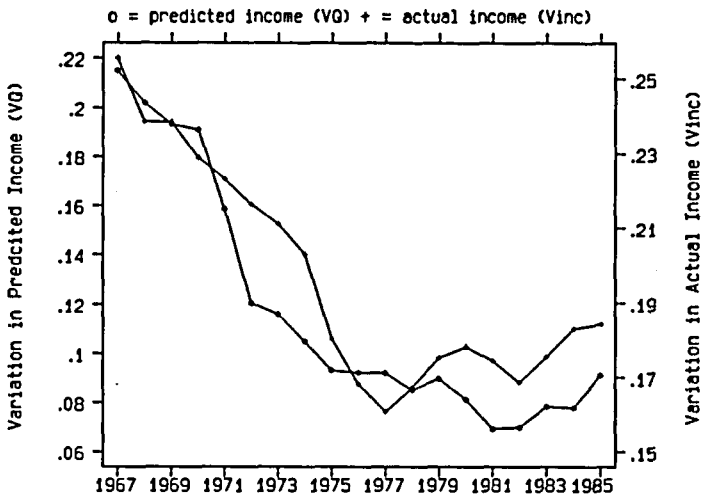

FIG. 1.—Variation in income predicted from education when prices are held fixed (VQ_t) alongside the variation in actual income ($Vinc_t$) for Europe.

over the last two decades has caused incomes to diverge substantially, as those countries that are better endowed with skilled labor reap the benefit of the rising premium.[7] However, in both these cases, this effect is offset by the reduction in income inequality resulting from education convergence.

[7] In this study the return to education is measured in terms of its contribution to GDP. Between 1967 and 1985, this increased by 58 percent for the developed countries and 64 percent for the developing countries.

The final two rows of table 2 reveal a significantly different pattern, however, when we consider the LDCs and the world as a whole. Despite substantial convergence in education levels, incomes within both these sets of countries have diverged. This is due almost entirely to movements in the rate of return to education. Whereas for the developed countries convergence in levels is the dominant force producing converging incomes, for the LDCs and the world as a whole the increase in inequality resulting from the rise in the skill premium dominates, leading to a divergence in incomes.

The role of prices and quantities for each of the subsamples is summarized in column 5 of table 2, which reports the relative contribution of quantities and prices to income convergence over the sample period. Among developed countries the contribution of education levels to income convergence is approximately 25 percent greater than the role of prices. As a result, the convergence in incomes resulting from convergence in education outweighs the effect of the increase in the return to education. At the world level, however, the impact of education levels is only 28 percent of the price effect, as a result of which inequality has increased.

The importance of factor price movements at the world level is a consequence of the large disparities that still exist in education levels across countries. Although average years of schooling increased by almost 60 percent among the LDCs between 1960 and 1985, by 1985 it was still only 3.37 years of schooling. While education levels grew more slowly among developed countries (a 40 percent increase over the same period), by 1985 the average education level in developed countries was 8 years of schooling, over twice that of the LDCs (Barro and Lee 1993). As a result of these differences, changes in production techniques that shift demand toward skilled labor, thus leading to higher returns to education, will tend to favor the developed countries at the expense of the LDCs, resulting in increased inequality.[8]

The analysis above uses school enrollment ratios to proxy for the stock of human capital. However, school enrollments measure additions to the stock of human capital rather than the stock itself. In a recent study, Barro and Lee (1993) use census information to assemble data on average years of schooling for most of the countries used in this study. These data are available at 5-year intervals from 1960 to 1985. While this limits one's ability to examine the temporal pattern of education convergence, it is possible to estimate the impact of education on income convergence over the sample period using this

[8] A similar explanation was given by Juhn, Murphy, and Pierce (1991) to explain the slowdown in black-white wage convergence in the United States since the mid 1970s.

TABLE 3

INDIVIDUAL CONTRIBUTION OF EDUCATION QUANTITIES, EDUCATION PRICES, AND RESIDUALS TO CHANGES IN THE VARIANCE OF INCOME BETWEEN 1970 AND 1985, WHEN AVERAGE YEARS OF SCHOOLING IS USED TO MEASURE EDUCATION

	Total Change in Income Variance (1)	Education Quantities (2)	Education Prices (3)	Residuals (4)	Ratio of Quantities to Prices* (5)
Developed countries	−.123	−.079	.077	−.121	1.03
Europe	−.045	−.108	.089	−.025	1.20
LDCs	.071	−.117	.259	−.071	.45
World	.249	−.179	.411	.017	.44

NOTE.—Col. 1 shows the change in the variance of income over the sample period. Cols. 2–4 give the contribution of the individual components calculated using the decomposition technique outlined in the paper. The analysis covers the period 1970–85 in order to keep the sample similar to that used earlier.

* In all cases the negative sign has been omitted.

measure of education. The results are presented in table 3 and are similar to those presented earlier using enrollment ratios.[9] In Europe and among the developed countries, the increase in income inequality arising from increases in the return to education is more than offset by the reduction in inequality arising from education convergence. For the world as a whole, however, we again find that the rising return to education is the dominant force accounting for the divergence in income.

These results also support the view that the relationship between education and income is causal from education to income rather than in the opposite direction. The reason is that the stock of human capital reflects the accumulation of past education flows and thus education choices made up to 20–30 years ago. Therefore, while enrollment ratios might respond to expected changes in income, the stock measure can be treated as predetermined and hence largely immune to the endogeneity problem.

It is apparent from these findings that the divergence in income between the LDCs and the developed world, despite significant convergence in education levels, should not be interpreted as a breakdown in the convergence mechanism arising from human capital changes. In fact the paper shows that quite the opposite is true. *Were it left to movements in education levels alone, incomes, both within the LDCs and between the LDCs and the developed countries, would have exhibited substantial convergence.*

[9] I am grateful to Robert Barro for providing me with these data.

IV. The Role of the Capital Stock in Determining the Income Distribution

To examine the extent to which factors other than human capital convergence can account for the changing pattern of income convergence, I repeated the decomposition, this time holding fixed the effect of education and examining instead the role of investment in physical capital. The results presented in table 4 suggest that, in contrast to changes in human capital, changes in physical capital as measured by investment per capita have little impact on the distribution of income. In particular, holding fixed the human capital distribution over time reduces the ability of observables to predict patterns of income dispersion for all the samples considered. The level of investment has no role to play in the changing income distributions of any of the subsamples studied, and investment prices appear to be important only at the world level. While large in magnitude, the movement in investment prices predicts convergence in income rather than the observed divergence.[10]

V. Summary and Conclusion

Much of the recent literature in economic growth has centered around the relative growth in income across countries and the extent to which incomes in poorer countries have converged to those of the richer countries. Two distinct patterns have emerged in these studies. On the one hand, the data show substantial convergence in income levels for a broad set of industrialized countries. Yet when we look at the world as a whole, no such convergence pattern emerges. In fact we note that the richer countries have tended to move further ahead of the LDCs.

In this paper, I examine the role played by human capital in accounting for these changes in the income distribution. I show that movements in the level of human capital provide a good predictor of the temporal pattern of income convergence among developed countries. More important, however, the paper shows how technological change may lead to a continued increase in income inequality at

[10] To examine the sensitivity of the results to the use of investment per capita, I repeated the decomposition using a measure of the capital stock constructed in a fashion similar to that used by Benhabib and Spiegel (1994). Using this measure, I find a greater role for physical capital in explaining income convergence. However, the construction of the capital stock is based on the assumption that prices are constant over time, which means that we cannot examine the impact of prices on income convergence using this measure. Furthermore, even with this stock measure, movements in human capital still provide a better predictor of the temporal pattern of income convergence than movements in physical capital.

TABLE 4

INDIVIDUAL CONTRIBUTION OF INVESTMENT QUANTITIES, INVESTMENT PRICES, AND RESIDUALS TO CHANGES IN THE VARIANCE OF INCOME BETWEEN 1967 AND 1985

	Total Change in Income Variance (1)	Investment Quantities (2)	Investment Prices (3)	Residuals (4)
Developed countries	−.167	.000	−.03	−.137
Europe	−.071	.000	−.016	−.055
LDCs	.148	−.013	.019	.142
World	.365	−.02	−1.23	1.62

NOTE.—Col. 1 shows the change in the variance of income over the sample period. Cols. 2–4 give the contribution of the individual components calculated using the decomposition technique outlined in the paper. The analysis covers the period 1967–85 because of the use of lagged schooling and investment variables.

the world level despite significant factor convergence. The recent shift in production techniques toward high-skilled labor has resulted in a substantial increase in the returns to education. This trend, when combined with the large disparities that still exist in education levels between the developed and less developed countries, has led to an increase in inequality despite the significant reduction in the education gap that has occurred over the last 20 years.

Appendix

TABLE A1

COUNTRIES IN THE SAMPLE BY DEVELOPED STATUS

Developed Countries			
Australia	Greece	Japan	Singapore
Austria	Holland	Korea	Spain
Belgium	Hong Kong	Malaysia	Sweden
Canada	Iceland	Malta	Trinidad
Denmark	Ireland	New Zealand	Turkey
Finland	Israel	Norway	United Kingdom
France	Italy	Portugal	United States
Germany			
Less Developed Countries			
Afghanistan	Dominican Republic	Lesotho	Rwanda
Algeria	Ecuador	Madagascar	Senegal
Argentina	Egypt	Malawi	Sierra Leone
Bangladesh	Ethiopia	Mali	Somalia
Barbados	El Salvador	Mauritania	Sri Lanka
Benin	Fiji	Mauritius	Sudan
Bolivia	Gambia	Mexico	Surinam
Botswana	Ghana	Morocco	Swaziland
Brazil	Guatemala	Mozambique	Syria
Burma	Guinea	Nepal	Tanzania
Burundi	Haiti	Nicaragua	Thailand
Cameroon	Honduras	Niger	Uganda
Central African Republic	India	Papua New Guinea	Uruguay
Chad	Indonesia	Pakistan	Venezuela
Chile	Ivory Coast	Panama	Zaire
Colombia	Jamaica	Paraguay	Zambia
Costa Rica	Kenya	Peru	
		Philippines	

NOTE.—This sample is based on that used by Tamura (1991*a*) and is very similar to the ranking of countries based on 1985 school enrollment ratios. I have also carried out the analysis using a ranking of countries based on 1960 school enrollment ratios and obtained very similar results. In particular, the rate of return to education using the new classification increased by 48 percent for the developed countries and 60 percent for the LDCs, compared to 58 percent and 64 percent with the classification above. Furthermore, the relative contribution of movements in education levels and education prices to income convergence at the world level is .31 with the new classification and .28 (col. 4 of table 2) with the original classification.

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