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Human Capital Convergence: A Joint Estimation Approach

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In the growth literature, evidence on convergence of per capita incomes is mixed. In the development literature, health and education indicators are often used to measure countries' development progress. This study examines whether average stocks of health and education are converging across countries and calculates the speed of their convergence using data from 84 countries for 1970–90. A three-stage least-squares (3SLS) procedure is used in a joint analysis of human capital convergence. The results confirm that investments in education and health are closely linked. The study finds unconditional convergence for life expectancy and infant survival, and for the stock of education as measured by average levels of total and secondary schooling in the adult population. [JEL O15, O40, J24, I19]

In the growth literature, considerable attention has been given to whether income per capita is unconditionally or conditionally converging across countries over time.[1] The evidence is mixed, and no firm conclusions have been

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[1]In the economic growth literature, unconditional convergence refers to the tendency of poor countries to grow faster than rich countries, and conditional convergence refers to convergence that is conditional on determinants of the steady-state income level.

reached (although the prevailing view generally favors an interpretation of unconditional divergence and conditional convergence). In the development literature, other indicators of national welfare besides per capita income—in particular, health and education levels—are often used as key social indicators to measure development progress. For example, the widely cited Human Development Index (HDI) (see United Nations Development Program, 2000) gives equal weights to income, health, and education in measuring countries' levels of development.

This study examines whether health and education levels are converging across countries. By taking a new look at human capital convergence, this study explicitly considers potential joint effects in the determination of changes in health and education capital. Our study is also the first to examine the rate of human capital convergence across countries (see also Sab and Smith, 2001). Our measures of human capital are life expectancy, the infant survival rate, and the average stocks of total and of secondary years of schooling. We use data from 84 countries for 1970–90. The countries included are listed in Table 1.

We then present evidence that education and health are joint investments with significant interaction effects at the aggregate level. In regression analyses, lagged dependent variables are used as instruments in a joint analysis of health and education convergence using a three-stage least-squares (3SLS) procedure in which one of the equations is related to growth in the education indicator and the other to growth in the health indicator. With unconditional convergence, the

Table 1. List of Countries Used in the Analysis

Afghanistan	El Salvador	Kuwait	Portugal	Uruguay
Algeria	Finland	Lesotho	Romania	Venezuela
Argentina	France	Malawi	Senegal	Zambia
Australia	Greece	Malaysia	Singapore	Zimbabwe
Austria	Guatemala	Mali	South Africa	
Bahrain	Guyana	Mauritius	Spain	
Belgium	Hong Kong SAR	Mexico	Sri Lanka	
Benin	Hungary	Myanmar	Sudan	
Botswana	Iceland	Nepal	Swaziland	
Brazil	India	Netherlands	Sweden	
Bulgaria	Indonesia	New Zealand	Switzerland	
Cameroon	Iran, I.R. of	Nicaragua	Syrian Arab Republic	
Canada	Iraq	Niger	Thailand	
Chile	Ireland	Norway	Togo	
Colombia	Israel	Panama	Trinidad and Tobago	
Costa Rica	Italy	Papua New Guinea	Tunisia	
Cuba	Jamaica	Paraguay	Turkey	
Denmark	Japan	Peru	Uganda	
Dominican Republic	Kenya	Philippines	United Kingdom	
Ecuador	Korea, Republic of	Poland	United States	

change in a human capital indicator is regressed on only its initial value. With joint human capital convergence, the change in an education (health) capital indicator is regressed on both its own initial value and the initial value of the health (education) indicator. Our first hypothesis is that education (health) human capital will grow faster in countries with low initial values of education (health), also after controlling for the initial value of health (education) human capital. Our second hypothesis is that countries with higher initial stocks of health (education) will have higher conditional growth rates of education (health). This joint human-capital growth analysis provides a test at the macro level of the long-hypothesized link between investments in education and health; and we find strong evidence for the validity of each of these hypotheses, although the impact of health on education is quantitatively much larger than that of education on health.

We conclude that the clear evidence that health and education are joint investments may offer scope for a more integrated policy approach. In particular, one of the most effective investments in enhancing the quality of education may be to improve child health. The results thus offer some support at the macro level for poverty programs that take an integrated approach to addressing education, health, and nutrition, such as Mexico's Progresa program, which addresses child health and education (SEDESOL, 2001), and the growing number of programs carried out by nongovernmental organizations (NGOs) that combine microenterprise credit with business training and measures to improve maternal and child health (Smith, 2002).

The data in this study are drawn from two sources: the World Bank's *World Development Indicators* for the stock of health capital and the dataset used by Barro and Lee (1996) for the stock of education. The sample uses data from 84 countries for 1970–90. The stock of education, *tyr*, is defined, as in the Barro and Lee dataset, as the average number of years of schooling in the adult population. The alternative Barro and Lee measure, *syr*, is the average number of years of secondary schooling in the adult population. Life expectancy at birth represents the number of years a newborn infant would live if prevailing age patterns of mortality at the time of its birth were to stay the same throughout its life. The infant survival rate is the difference between 1,000 live births and the infant mortality rate (the number of infants per each 1,000 live births who die before reaching one year of age).

I. A Brief Literature Review

There is a substantial literature examining the extent to which per capita incomes are converging across countries over time. The pioneering work of Barro (1991) and Mankiw, Romer, and Weil (1992) demonstrated that the cross-country data can be read as consistent with either income nonconvergence or convergence; and the extensive research conducted over the intervening years has not produced a consensus (Pritchett, 1997; and Jones, 1997).

At the same time, there have been a large number of studies in the literature confirming the importance of education, and more recently of health, in economic development. Nevertheless, there have been relatively few studies analyzing trends in the indicators of human capital and the possible convergence of health and education levels across countries.

Babini (1991) examined coefficients of variation for education indicators for a sample of countries over the period 1960–83. Since the coefficient of variation in the sample declined for enrollment rates at the primary, secondary, and tertiary levels of education, she concluded that these indicators were converging. She found the highest convergence at the primary level.

Ingram (1994) analyzed social indicators and productivity convergence in three developing country samples grouped according to income levels, using three measures of convergence: (1) the elasticity of the social indicator, obtained by regressing the indicator on per capita GDP in each sample in a given year; (2) the coefficient of variation; and (3) the disparity in mean values of the indicators over time across country groups. Ingram concluded that life expectancy and primary school enrollment are converging over time.

In a cross-country growth framework, O'Neill (1995) presents evidence that convergence in education (using an enrollment-ratio measure) has resulted in less income dispersion among the sample of developed countries; but for the world sample, incomes have diverged despite significant convergence in the quantity of education. He concludes that the discrepancy results from increases in the returns to education that favor developed countries.

Cohen (1996) examined convergence of measured inputs across countries; his dependent variables were average growth rates for 1965–85 of the stock of physical capital per worker and of the stock of human capital per worker (average years of school completed by the working population). His 3SLS results indicated convergence in education and physical capital.

There is a long tradition in economics generally, and development economics in particular, of viewing health and education as joint investments. As Mushkin (1962) put it, "health and education are joint investments made in the same individual. The individual is more effective in society as a producer and as a consumer because of these investments. And often the return on investment in health is attributed to education." In particular, she argued that "a lengthening of life expectancy through improved health reduces the rate of depreciation of investment in education and increases the return to it."

Barro (1997) includes male and female education and life expectancy in growth regressions. His results suggest that years of schooling at the secondary and tertiary levels for males age 25 and over have a strong positive conditional effect on the rate of growth. Perhaps surprisingly, Barro finds that education for females at various levels has no direct effect on growth, though he acknowledges that it enhances per capita income growth indirectly by lowering fertility.

In contrast, microeconomic studies find that the education of girls has a higher social return than the education of boys, at least in part because educating girls is associated with a reduction in child mortality, decreased fertility, and increased educational achievement of the recipients' own children (Schultz, 1992).

A number of prominent poverty programs in developing countries explicitly integrate incentives to upgrade human capital among low-income families by improving their health and education. A well-known example is that of the

Mexican Progresa program, which has as one of its central features the promotion of a package integrating education, health, and nutrition. From its launching in August 1997, the program has covered some 2.47 million households (SEDESOL, 2001). Preliminary evaluations of this program (Hoddinott and Skoufias, 2001; and Schultz, 2001) indicate that its integrated approach has been quite successful.

The linkages between education and health are potentially quite extensive. On the one hand, improving health may improve the return on investments in education, in part because health is an important factor in school attendance and in the formal learning process of children. A longer life also raises the return on investments in education; and better health at any point during a person's working life may, in effect, lower the rate of depreciation of his or her education capital. On the other hand, greater education capital may improve the return on investments in health, because many health programs rely on basic skills often learned at school, including personal hygiene and sanitation, as well as basic literacy and numeracy; and education also makes it possible to hire and train health personnel. Finally, improvements in productive efficiency resulting from investments in education raise the returns on lifesaving investments in health.

II. Examining Human Capital Convergence with 3SLS

As noted earlier, there are good reasons to anticipate that investments in education and health may strongly interact. Building on the literature reviewed in Section I, we consider the convergence of health and education human capital.

In this paper, we examine human-capital convergence in the following estimation framework:

$$\ln\left(\frac{edu_{i,90}}{edu_{i,75}}\right) = \beta_{01} + \beta_{11}\ln\left(edu_{i,75}\right) + \beta_{21}\ln\left(life_{i,75}\right) + e_{1,i} \tag{1}$$

$$\ln\left(\frac{life_{i,90}}{life_{i,75}}\right) = \beta_{02} + \beta_{12}\ln\left(edu_{i,75}\right) + \beta_{22}\ln\left(life_{i,75}\right) + e_{2,i}, \tag{2}$$

where the left-hand sides of equations (1) and (2) represent, respectively, the difference of logs for education indicators (average years of education in the total population or average years of secondary education, depending on the specification) and the difference of logs for health (life expectancy or infant survival, depending on the specification) for the period 1970–90; and *i* denotes a country index. The right-hand sides of these equations are the corresponding initial 1975 values of the proxies for education and health, and *e* denotes the error term.

In our first estimation strategy, we assume that

$$\beta_{12} = \beta_{21} = 0. \tag{3}$$

These equations are estimated jointly using 3SLS, and the instruments are the 1970 values of the right-hand-side variables.[2]

Table 2 reports results for unconditional human capital convergence with 3SLS. As indicated in regression set (2.1), in equation (2.1.1) the coefficient on initial total years of schooling, *tyr*, is negative and statistically significant at the 1 percent level, while in equation (2.1.2), the coefficient on initial life expectancy is also negative and statistically significant at the 1 percent level, indicating convergence of each variable.[3] The speed of convergence for *tyr*, λ, is 0.023, implying that this variable moves halfway to the steady state in about 30 years.[4] In contrast, the value of λ for life expectancy is 0.010, implying that this variable moves halfway to the steady state in about 69 years.[5]

Regression set (2.2) in Table 2 shows the corresponding equations for growth of *tyr* and the infant survival rate (*sur*); in equations (2.2.1) and (2.2.2), the coefficients on the initial value of *tyr* and *sur* are also negative and significant at the 1 percent level. The speed of convergence for both *tyr* and *sur* are 0.023, again implying a half-life of about 30 years.

Equations (2.3.1) and (2.3.2) similarly show that the coefficients on the initial value of our alternative education variable, the average years of secondary education in the adult population (*syr*), and life expectancy are negative and statistically significant at the 1 percent level. These results again indicate unconditional convergence; the speeds of convergence are 0.016 and 0.010, respectively. This implies half-lives of 43 years for secondary schooling and 69 years for life expectancy.

Finally, equations (2.4.1) and (2.4.2) also show convergence at the 1 percent level when *syr* and *sur* are examined together. In this case, the speeds of convergence are 0.016 and 0.020, giving estimated half-lives of 43 and 35 years, respectively.

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[2]Results were generated using the 3SLS procedure in the LIMDEP package, which—except for using instrumental variables—otherwise follows the generalized-least-squares (GLS) estimator for the seemingly unrelated linear regressions (SURE) model.

[3]A negative coefficient on a lagged dependent variable implies that with an initially lower level, a country will experience higher growth in that variable.

[4]The speed of convergence, λ, of a given variable is calculated by taking the negative of the natural log of one plus the coefficient on the lagged dependent variable divided by the period under observation. Thus, from equation (1), $\lambda_l = -\ln(1 + \beta_{11})/\tau$ and from equation (2), $\lambda_2 = -\ln(1 + \beta_{22})/\tau$ where τ is the period in the analysis. The half-life, t^*, is the solution to $e^{-\lambda t^*} = 0.5$. Taking logs of both sides, $t^* = -\ln(0.5)/\lambda$. Note that because we are instrumenting for our endogenous variables, our estimates are consistent for the parameters of interest in equations (1) and (2) and therefore they can be interpreted as approximations of those parameters. Thus, because in this case the parameters of interest have a speed-of-convergence interpretation, which, if known, could permit one to make half-life statements, then our consistent parameter estimates directly yield estimates of the speed of convergence with no further adjustments required. This is a special case of the general rule that given a structural equation within a system of equations, the coefficients in that equation can be interpreted without reference to the other structural equations in that system.

[5]As a robustness check, we also ran fixed-effect estimations over five-year intervals and found that the fixed-effect coefficients do not vary statistically across countries. This indicates that countries are converging to a common steady state. We have also examined averages and endpoints, and considered alternative time periods, using different measures for education capital, including enrollment rates and gender disparity measures. See also Sab and Smith (2001). In all cases, the results were qualitatively the same as those we report in the paper. These sensitivity regressions are available from the authors on request.

Table 2. Analysis of Unconditional Human Capital Convergence with 3SLS

(dependent variables: log difference for average years of schooling and health indicators, 1970–90)

	Regression (2.1)			Regression (2.2)	
	Equation (2.1.1) *Dtyr*	Equation (2.1.2) *Dlife*		Equation (2.2.1) *Dtyr*	Equation (2.2.2) *Dsur*
Observations	84	84		84	84
Constant	0.71*** (0.037)	0.67*** (0.106)	Constant	0.71*** (0.037)	2.01*** (0.221)
ln (*tyr*75)	–0.29*** (0.025)		ln (*tyr*75)	–0.30*** (0.025)	
ln (*life*75)		–0.14*** (0.026)	ln (*sur*75)		–0.29*** (0.032)
λ	0.023*** (0.002)	0.010*** (0.002)	λ	0.023*** (0.002)	0.023*** (0.003)
	Regression (2.3)			**Regression (2.4)**	
	Equation (2.3.1) *Dsyr*	Equation (2.3.2) *Dlife*		Equation (2.4.1) *Dsyr*	Equation (2.4.2) *Dsur*
Observations	84	84		84	84
Constant	0.51*** (0.038)	0.62*** (0.107)	Constant	0.51*** (0.038)	1.95*** (0.221)
ln (*syr*75)	–0.22*** (0.030)		ln (*syr*75)	–0.22*** (0.029)	
ln (*life*75)		–0.13*** (0.026)	ln (*sur*75)		–0.28*** (0.032)
λ	0.016*** (0.003)	0.010*** (0.002)	λ	0.016*** (0.003)	0.020*** (0.003)

Notes: Standard errors are in parentheses. R^2 is not reported, since it is not bounded between 0 and 1. Three asterisks (***) denote significance at 1 percent, two (**) significance at 5 percent, and one (*) significance at 10 percent. *Dtyr* denotes the log difference for average years of schooling in the total population, *Dsyr* the log difference for average years of secondary schooling in the total population, *Dlife* the log difference for life expectancy, *Dsur* the log difference for the infant survival rate, *tyr*75 average years of schooling for the total population in 1975, *syr*75 average years of secondary schooling for the total population in 1975, *life*75 life expectancy in 1975, and *sur*75 the infant survival rate in 1975.

We now examine joint human capital effects more explicitly by conditioning health improvement on initial education and conditioning education improvement on initial health. Our first hypothesis is that education (health) human capital will grow faster in countries with low initial values of education (health), after controlling for the initial values of their health (education). Our second hypothesis is that countries with higher initial health (education) will have higher conditional growth rates of education (health).

Our approach is similar to Cohen's (1996) analysis of convergence of inputs in the aggregate production function.[6] We use a 3SLS procedure with instrumental variables in our analysis of joint human capital convergence because of the several potential joint effects across health and education, which were described in Section I. Thus, we are now estimating the full specification given by equations (1) and (2).

Moreover, as an additional test, following Cohen (1996), there will be evidence for joint convergence in human capital if the following conditions hold in equations (1) and (2):[7]

$$\beta_{11} + \beta_{22} < 0, \tag{4}$$

$$\beta_{11}\beta_{22} - \beta_{12}\beta_{21} > 0. \tag{5}$$

Table 3 reports joint human capital convergence for average years of total schooling and average years of secondary school and life expectancy and infant survival. Regression set (3.1) reports results for growth of *tyr* and life expectancy. As seen in equation (3.1.1), the coefficient on the initial value of *tyr* has a negative and statistically significant coefficient at the 1 percent level, indicating that a country starting with an initially low *tyr* will experience faster-than-average conditional growth in *tyr*, other things being equal. The coefficient on life expectancy (cross effect) is positive at the 1 percent level, indicating that higher initial levels of health lead to faster subsequent growth in the stock of education. The eigenvalue restriction tests given by equations (4) and (5) in the text also hold at the 1 percent level. In contrast, in equation (3.1.2), none of the coefficients are statistically significant. However, in regression set (3.2), all the signs are as predicted, with the initial infant survival rate positively affecting growth of the total years of schooling at the 1 percent significance level. Finally, in regression sets (3.3) and (3.4), all coefficients are statistically significant, with the predicted signs.

Thus, while none of the results in Table 3 are inconsistent with the hypothesis of health and education as joint investments, regression sets (3.3) and (3.4) offer particularly compelling evidence of joint human capital convergence. We conjecture that the reason for the stronger results in regression sets (3.3) and (3.4) compared with regression sets (3.1) and (3.2) is that *tyr* includes primary education,

[6]As left-hand-side variables, Cohen used the average growth rates for 1965–85 of the per worker stock of physical and human capital, while the right-hand-side variables were the corresponding initial 1965 values.

[7]These are, of course, just eigenvalue stability conditions for a pair of difference equations. As Cohen interprets them, "in that case poor countries' resources are appropriately rising over the years and asymptotically converge to the rich countries' endowments." This provides a test of convergence for the system of equations.

Table 3. Analysis of Joint Human Capital Convergence with 3SLS

(dependent variables: log difference for average years of schooling and health indicators, 1970–90)

	Regression (3.1)			Regression (3.2)	
	Equation (3.1.1) *Dtyr*	Equation (3.1.2) *Dlife*		Equation (3.2.1) *Dtyr*	Equation (3.2.2) *Dsur*
Observations	84	84		84	84
Constant	–4.69***	0.38**	Constant	–25.9***	2.18***
	(0.759)	(0.191)		(4.648)	(0.400)
ln (*tyr*75)	–0.52***	-0.01	ln (*tyr*75)	–0.48***	0.003
	(0.038)	(0.010)		(0.039)	(0.003)
ln (*life*75)	1.37***	–0.07	ln (*sur*75)	3.92***	–0.32***
	(0.193)	(0.048)		(0.685)	(0.059)
$\beta_{11}+\beta_{22}<0$	–0.59***		$\beta_{11}+\beta_{22}<0$	–0.80***	
	(0.057)			(0.063)	
$\beta_{11}\beta_{22}–\beta_{12}\beta_{21}>0$	0.055***		$\beta_{11}\beta_{22}–\beta_{12}\beta_{21}>0$	0.14***	
	(0.016)			(0.02)	
λ	0.049***	0.005	λ	0.044***	0.025***
	(0.005)	(0.003)		(0.005)	(0.006)

	Regression (3.3)			Regression (3.4)	
	Equation (3.3.1) *Dsyr*	Equation (3.3.2) *Dlife*		Equation (3.4.1) *Dsyr*	Equation (3.4.2) *Dsur*
Observations	84	84		84	84
Constant	–6.83***	0.94***	Constant	–31.0***	2.49***
	(1.501)	(0.224)		(8.05)	(0.422)
ln (*syr*75)	–0.45***	0.01*	ln (*syr*75)	–0.39***	0.005*
	(0.055)	(0.008)		(0.053)	(0.003)
ln (*life*75)	1.75***	–0.21***	ln (*sur*75)	4.59***	–0.36***
	(0.357)	(0.05)		(1.173)	(0.062)
$\beta_{11}+\beta_{22}<0$	–0.66***		$\beta_{11}+\beta_{22}<0$	–0.75***	
	(0.069)			(0.073)	
$\beta_{11}\beta_{22}–\beta_{12}\beta_{21}>0$	0.07***		$\beta_{11}\beta_{22}–\beta_{12}\beta_{21}>0$	0.12***	
	(0.015)			(0.020)	
λ	0.04***	0.01***	λ	0.033***	0.030***
	(0.007)	(0.004)		(0.006)	(0.006)

Notes: Standard errors are in parentheses. R^2 is not reported, since it is not bounded between 0 and 1. Three asterisks (***) denote significance at 1 percent, two (**) significance at 5 percent, and one (*) significance at 10 percent. *Dtyr* denotes the log difference for average years of schooling in the total population, *Dsyr* the log difference for average years of secondary schooling for the total population, *Dlife* the log difference for life expectancy, *Dsur* the log difference for the infant survival rate, *tyr*75 average years of schooling for the total population in 1975, *syr*75 average years of secondary schooling for the total population in 1975, *life*75 life expectancy in 1975, and *sur*75 the infant survival rate in 1975.

thereby reducing measured variability in the stock of education across countries. In addition to this statistical explanation, an important economic effect may also be present: the stock of secondary education may have a larger impact in improving a country's average level of health than primary education does.

From the results in this section, we can conclude that, in general, there is joint convergence in health and education across countries. This convergence extends to both life expectancy and infant survival.

As may be seen in Table 3, the cross effects between education and health are very different in magnitude. On the one hand, the impact of higher levels of initial health on the education capital growth is much larger quantitatively, and in some cases statistically, than the impact of higher levels of initial education on health capital growth. For example, in regression set (3.3), the results indicate that a 1 percent higher initial life expectancy leads to about a 1.75 percent improvement in the growth of average years of secondary education. On the other hand, a 1 percent increase in the average years of secondary education leads to just a 0.01 percent improvement in the growth of life expectancy. As may be seen in regression sets (3.1) and (3.2), the effect of initial years of total schooling on life expectancy growth and infant survival improvement is not even statistically significant. These results may suggest that it is intrinsically more difficult to extend life than to improve educational levels, but they may also indicate that health plays a greater role in the accumulation of education capital than education plays in the accumulation of health capital.

III. Conclusions

In this paper, we have used a 3SLS approach to allow us to capture the hypothesized links between education and health. These links were particularly evident when we used average years of secondary education as our proxy for the stock of education. Several explanations for these links have been reviewed in the paper, including the greater incentives to upgrade human capital with a longer life expectancy and for a child with better health to perform better in school. At the same time, an individual with more education will be endowed with basic hygiene and sanitation skills learned at school, as well as the knowledge needed to improve the health of his or her children. In addition, skills developed at higher levels of education, including medical education, may be used directly or indirectly to improve the overall level of health in society.

Our findings of human capital convergence represent good news for development, viewed in the broad sense of encompassing improved health and education as objectives in their own right, alongside increased per capita incomes. Our findings may also be good news for eventual conditional income convergence. Both health and education capital are understood to be important inputs in the aggregate production function and important determinants of the possibilities for low-income countries to rapidly catch up with the developed world. The fact that human capital convergence has not yet translated unambiguously into international income convergence likely reflects three factors. First, most developing countries still have very young populations; there is likely to be a substantial lag between human capital accumulation and increased productivity and incomes.

Second, education is likely to be an input that is complementary to other factors; Romer's (1993) suggestion that rapid development results from the interaction of human capital with the availability of productive ideas is particularly instructive in this context. Developing countries will need to increase their rates of technology transfer, which will require increased openness of their economies as well as increased international assistance. Third, the general policy environment is also a significant determinant of the incentives to use education capital productively. Continued efforts will be needed to improve the policy environment to raise the return on using education for productive activities rather than for rent seeking.

Improvement in health and education standards in developing countries and their convergence toward the standards of developed countries has been due in part to governments' policies. In addition, aid agencies, notably including both international and nongovernmental organizations (NGOs), have also played critical roles in recent decades in improving health and education. These efforts have brought modern public health practices and basic schooling opportunities to even remote rural areas of Africa, Asia, and Latin America, resulting in improvements in the infant survival rate and bringing the goal of universal primary education within reach. Despite the positive trends, and the encouraging results of this research, however, this is clearly no time for complacency on the part of the international community, since infant survival remains tragically, and unnecessarily, low in the poorest countries. Efforts being made to address the current health crises in Africa (notably HIV/AIDS, tuberculosis, and malaria) will need to receive additional resources to ensure that a catastrophic loss of the hard-won gains of the last decades is avoided.

Even without the dangers posed by the spread of infectious diseases, the fact that life expectancies are converging around the world at the rates this study has found offers no grounds for complacency. In fact, we may anticipate that the rate of convergence makes for some rather grim news for a typical villager living in Africa or South Asia. For example, with a life expectancy convergence rate of 0.01, the message is bleak: "You will die 20 years sooner than your counterpart in the developing world. But, 70 years from now, your grandchild or great-grandchild will die only 10 years sooner than his or her counterpart there." This news is unlikely to prove very reassuring.

The clear evidence that health and education are joint investments may offer scope for a more integrated policy approach. It may be that one of the most effective investments we can make in education quality is to improve child health. Similarly, one of the most effective investments we can make in health may be to improve the quality of education. The results thus offer some support at the macro level for poverty programs, such as Mexico's Progresa (SEDESOL, 2001), that take an integrated approach to addressing education, health, and nutrition.

In fact, the results in this paper strongly suggest that these effects are not symmetric: there is a much larger effect of initial health on education growth than of initial education on health growth. Although it would be premature to use these results alone to guide the design of policy on such an important question, the results certainly suggest that improving health is more critical to successfully improving education than improving education is to successfully improving health. This will be a very valuable topic to explore in future research.

REFERENCES

Babini, Ana Maria Eichelbaum de, 1991, "Convergence and Divergence of Education Systems in Today's World," *Prospects*, Vol. 21, No. 3, pp. 330–39.

Barro, Robert, 1991, "Economic Growth in a Cross Section of Countries," *Quarterly Journal of Economics*, Vol. 106 (May), pp. 407–43.

———, 1997, *Determinants of Economic Growth: A Cross-Country Empirical Study* (Cambridge, Massachusetts: MIT Press).

———, and Jong Wha Lee, 1996, "International Measures of Schooling Years and Schooling Quality," *American Economic Review, Papers and Proceedings*, Vol. 86 (May), pp. 218–23. The dataset used to produce this article is available for downloading on the web at *http://www.worldbank.org/research/growth/ddbarle2.htm.*

Cohen, Daniel, 1996, "Tests of the 'Convergence Hypothesis': Some Further Results," *Journal of Economic Growth*, Vol. 1 (September), pp. 351–61.

Hoddinott, John, and Emmanuel Skoufias, 2001, "Preliminary Evidence on the Impact of Progresa on Consumption," paper presented at the American Economic Association's annual meeting, New Orleans (January).

Ingram, Gregory K., 1994, "Social Indicators and Productivity Convergence in Developing Countries," in *Convergence of Productivity: Cross-National Studies and Historical Evidence*, ed. by William J. Baumol, Richard R. Nelson, and Edward N. Wolff (Oxford and New York: Oxford University Press), pp. 316–33.

Jones, Charles I., 1997, "Convergence Revisited," *Journal of Economic Growth*, Vol. 2 (June), pp. 131–53.

Mankiw, N. Gregory, David Romer, and David N. Weil, 1992, "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics*, Vol. 107 (May), pp. 407–37.

Mushkin, Selma J., 1962, "Health as an Investment," *Journal of Political Economy*, Vol. 70 (October), pp. 129–57.

O'Neill, Donal, 1995, "Education and Income Growth: Implications for Cross-Country Inequality," *Journal of Political Economy*, Vol. 103 (December), pp. 1289–301.

Pritchett, Lant, 1997, "Divergence, Big Time," *Journal of Economic Perspectives*, Vol. 11, No. 3, pp. 3–17.

Romer, Paul, 1993, "Idea Gaps and Object Gaps in Economic Development," *Journal of Monetary Economics*, Vol. 32 (December), pp. 543–73.

Sab, Randa, and Stephen C. Smith, 2001, "Human Capital Convergence: International Evidence," IMF Working Paper 01/32 (Washington: International Monetary Fund).

Schultz, T. Paul, 1992, "The Role of Education and Human Capital in Economic Development: An Empirical Assessment," Economic Growth Center Discussion Paper No. 670 (New Haven, Connecticut: Yale University).

———, 2001, "The Impact of Progresa on School Enrollment," paper presented at the American Economic Association's annual meeting, New Orleans (January).

Secretaría de Desarrollo Social (SEDESOL), 2001, Government of Mexico, *Programa de Educación, Salud y Alimentación (Progresa)*, available on the web at *http://www.progresa.gob.mx.*

Smith, Stephen C., 2002, "Village Banking and Maternal and Child Health: Evidence from Ecuador and Honduras," *World Development*, Vol. 30 (April), pp. 707–23.

United Nations Development Program, 2000, *Human Development Report* (New York).

World Bank, 2001, World Bank Indicators database, available on the web at *http://www.worldbank.org/data/databytopic/GNPPC.pdf*