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The Contribution of Education to Economic Growth: A Review of the Evidence, with Special Attention and an Application to Sub-Saharan Africa

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Summary. — This paper examines recent studies that estimate the impact of education on economic growth. It explains why cross-country regressions face formidable econometric problems. Recent studies are reviewed: some show strong impacts of education on economic growth; others show little effect. All have multiple estimation problems, which may explain their divergent results. Evidence shows that education quality in Sub-Saharan Africa is much lower than in other developing countries. Estimates from three influential studies are extended; the results suggest that the impact of education on economic growth in Sub-Saharan Africa is lower than in other countries, likely due to lower school quality.

Key words — education, economic growth, Sub-Saharan Africa, school quality

1. INTRODUCTION

From 1980 to 2000, Sub-Saharan African countries experienced low economic growth and made little progress in raising their levels of education. More specifically, World Bank data show that from 1980 to 2000 the average growth rate in Gross Domestic Product (GDP) per capita in Sub-Saharan Africa was −0.6%, which compares to 4.9% in East Asia, 0.5% in Latin America, 1.2% in the Middle East, and 3.6% for South Asia. Further, from 1980 to 2000 the primary school gross enrollment rate in Sub-Saharan Africa *declined*, from 80% to 77%. In contrast, over the same period the primary gross enrollment rate increased, or held steady at a high level, in East Asia (111% in both years), Latin America (from 105% to 127%), the Middle East (89% to 97%), and South Asia (77% to 98%). (These figures are from Glewwe & Kremer, 2006.) On a more optimistic note, the average GDP growth per capita in Sub-Saharan Africa from 2000 to 2010 was about 2.5%, and the primary gross enrollment rate had increased to 100% in 2010 (World Bank, 2012).

These two phenomena are almost certainly related. If education makes individuals more productive workers, the lack of progress in education outcomes in Sub-Saharan Africa in the 1980s and 1990s may explain, at least in part, its low economic growth. There may also be a causal relationship in the other direction: low incomes reduce households' capacity to send their children to school.

This paper examines recent macroeconomic research on the impact of education on economic growth, focusing on Sub-Saharan Africa. It first reviews recent models of economic growth (Section 2), emphasizing the difficulties in estimating the impact of education and other factors on economic growth. It then reviews recent studies of the impact of education on economic growth (Section 3). Finally, it presents new estimates of the impact of education on growth that focus on Sub-Saharan Africa (Section 4). The last section summarizes the findings and provides suggestions for future research.

2. METHODOLOGICAL ISSUES IN ESTIMATING THE DETERMINANTS OF ECONOMIC GROWTH

To provide a framework for interpreting the results of empirical studies, this section reviews basic neoclassical growth theory, focusing on its implications for estimating the determinants of economic growth. For further details, see the comprehensive review by Durlauf, Johnson, and Temple (2005).

(a) *Basic growth theory*

Before examining theoretical models, the basic variables must be defined. They are (where i denotes country and t denotes year):

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$Y_{i,t}$	total output
$L_{i,t} = L_{i,0}e^{n_i t}$	total labor (which grows at rate n_i)
$y_{i,t} = Y_{i,t}/L_{i,t}$	output per worker
$A_{i,t} = A_{i,0}e^{g_i t}$	level of (labor augmenting) technological progress
$y^E_{i,t} = Y_{i,t}/(L_{i,t}A_{i,t})$	output per "efficiency unit of labor"

The last variable, $y^E_{i,t}$, requires some explanation. The denominator, $L_{i,t}A_{i,t}$, is "efficiency units of labor," that is the amount of labor at time t *measured in terms of the efficiency of labor at time zero*. For example, if there are 100 workers at both time 0 and time t, but technical change makes labor 30% more efficient, then there are 130 efficiency units of labor at time t. Note that efficiency units of labor grow at the rate $n_i + g_i$: $L_{i,t}A_{i,t} = L_{i,0}A_{i,0}e^{(n_i+g_i)t}$. In general, as long as there is technical change of some sort, output per capita, $y_{i,t}$, grows even when the economy is in equilibrium. In contrast, in most growth models output per efficiency unit of labor, $y^E_{i,t}$, is constant in equilibrium. The point here is that it is useful to have a measure of output per capita that "nets out" exogenous improvements in technology and thus converges to a constant in equilibrium.

Standard one-sector neoclassical growth models imply that the average (annual) rate of income growth per worker from time 0 to time t in country i, denoted by γ_i, equals: [1]

$$\gamma_i = g_i + \beta_i[\log(y_{i,0}) - \log(y^E_{i,\infty}) - \log(A_{i,0})] \tag{1}$$

where g_i is the rate of (labor augmenting) technological change, $y_{i,0}$ is income per worker at time 0, $y^E_{i,\infty}$ is the steady state value of income *per efficiency unit of labor*, and $A_{i,0}$ is labor efficiency at time zero. Rewriting Eqn. (1) yields a useful interpretation:

$$\begin{aligned}\gamma_i &= g_i + \beta_i[\log(y_{i,0}/A_{i,0}) - \log(y^E_{i,\infty})] \\ &= g_i + \beta_i[\log(y^E_{i,0}) - \log(y^E_{i,\infty})]\end{aligned} \tag{1'}$$

Eqn. (1′) shows that the rate of growth per worker from time 0 to time t equals g_i, the rate of technical change for country i (which in simple models is treated as exogenous), plus the difference between the initial value ($y^E_{i,0}$) and the long-run equilibrium value ($y^E_{i,\infty}$) of output per efficiency unit of labor.

In general, countries' initial level of output per efficiency unit of labor would be less than the equilibrium level, so that the term in brackets would be negative. Standard growth theory implies that $\beta_i < 0$, so Eqn. (1) shows that countries with initial levels of output per efficiency unit of labor far below their equilibrium levels will have relatively high rates of economic growth. This implies that, everything else equal, poor countries should have higher rates of economic growth and so should "catch up" to wealthier countries. Finally, note that β_i in Eqn. (1) measures the speed of convergence of economic growth to the steady state. Over time, β_i diminishes and eventually equals zero (see Durlauf *et al.*, 2005, p. 577). Thus in the very long run the rate of economic growth equals the rate of technological progress, g_i.

How is Eqn. (1) related to estimates of the determinants of economic growth? Most studies assume that g_i and β_i do not vary over countries, and add an error term, u_i:

$$\gamma_i = g - \beta\log(y^E_{i,\infty}) - \beta\log(A_{i,0}) + \beta\log(y_{i,0}) + u_i \tag{2}$$

Data are usually available for $y_{i,0}$, but finding data on $y^E_{i,\infty}$ and $A_{i,0}$ is more difficult.

Mankiw, Romer, and Weil (1992) connected growth theory with empirical growth regressions by assuming that total output of country i at time t ($Y_{i,t}$) is determined by three factors: physical capital ($K_{i,t}$), human capital ($H_{i,t}$), and labor ($L_{i,t}$). Specifically, they assumed a standard constant returns to scale Cobb–Douglas production function: [2]

$$Y_{i,t} = K^{\alpha}_{i,t}H^{\phi}_{i,t}(A_{i,t}L_{i,t})^{1-\alpha-\phi} \tag{3}$$

where labor is multiplied by technical efficiency ($A_{i,t}$) to generate "efficiency units of labor." They also assumed exogenous growth for labor supply and technical change:

$$L_{i,t} = L_{i,0}e^{n_i t},\ A_{i,t} = A_{i,0}e^{gt} \tag{4}$$

where g is the same rate of growth in Eqn. (2). They allow labor supply growth (i.e., population growth) to vary by country, but assume that growth in technological progress is the same for all countries.

In contrast, physical and human capital growth rates are determined by country-specific savings rates for those types of capital ($s_{K,i}$ and $s_{H,i}$, respectively) and by their depreciation rates. Thus their changes over time (denoted by $\dot{K}_{i,t}$ and $\dot{H}_{i,t}$) are:

$$\dot{K}_{i,t} = s_{K,i}Y_{i,t} - \delta K_{i,t} \tag{5}$$

$$\dot{H}_{i,t} = s_{H,i}Y_{i,t} - \delta H_{i,t} \tag{6}$$

where the depreciation rate (δ) is assumed not to vary over countries, or by the type of capital. In contrast, savings rates can vary over countries and by type of capital, but not over time.

Mankiw, Romer, and Weil show that these assumptions yield the following solution for $y^E_{i,\infty}$, the steady state level of income per efficiency unit of labor:

$$Y^E_{i,\infty} = \left(\frac{s^{\alpha}_{K,i}s^{\phi}_{H,i}}{(n_i + g + \delta)^{\alpha+\phi}}\right)^{\frac{1}{1-\alpha-\phi}} \tag{7}$$

Note that $y^E_{i,\infty}$ does not change over time, yet it varies across countries according to their savings rates for physical and human capital and their labor force growth (n_i).

(b) *From theory to econometric specification*

Insert (7) into (2):

$$\begin{aligned}\gamma_i = {} & g + \beta\log(y_{i,0}) + \beta\frac{\alpha+\phi}{1-\alpha-\phi}\log(n_i + g + \delta) \\ & - \beta\frac{\alpha}{1-\alpha-\phi}\log(s_{K,i}) - \beta\frac{\phi}{1-\alpha-\phi}\log(s_{H,i}) \\ & - \beta\log(A_{i,0}) + u_i\end{aligned} \tag{8}$$

The only unobserved country-specific term is $A_{i,0}$. Mankiw and his coauthors assume that $\log(A_{i,0}) = \log(A) + e_i$, where e_i is a country-specific random shock that is uncorrelated with n_i, $s_{K,i}$ and $s_{H,i}$. This gives:

$$\begin{aligned}\gamma_i = {} & g - \beta\log(A) + \beta\log(y_{i,0}) + \beta\frac{\alpha+\phi}{1-\alpha-\phi}\log(n_i + g + \delta) \\ & - \beta\frac{\alpha}{1-\alpha-\phi}\log(s_{K,i}) - \beta\frac{\phi}{1-\alpha-\phi}\log(s_{H,i}) + \varepsilon_i\end{aligned} \tag{9}$$

where $\varepsilon_i = u_i - \beta e_i$.

Eqn. (9) provides a theoretical foundation for estimating the determinants of economic growth; indeed, it is the basis of the regressions in Mankiw *et al.*, and in many subsequent papers. Consider Eqn. (9). Apart from the constant, $g - \beta\log(A)$, it has four coefficients but only three parameters (β, α and ϕ). This occurs because the sum of the coefficients on $\log(n_i + g + \delta)$, $\log(s_{K,i})$ and $\log(s_{H,i})$ equals zero. This parameter