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Higher Education and Economic Growth in Africa

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ABSTRACT *This paper uses panel data over the 1960–2000 period, a modified neoclassical growth equation, and a dynamic panel estimator to investigate the effect of higher education human capital on economic growth in African countries. We find that all levels of education human capital, including higher education human capital, have positive and statistically significant effect on the growth rate of per capita income in African counties. Our result differs from those of earlier research that find no significant relationship between higher education human capital and income growth. We estimate the growth elasticity of higher education human capital to be about 0.09, an estimate that is twice as large as the growth impact of physical capital investment. While this is likely to be an overestimate of the growth impact of higher education, it is robust to different specifications and points to the need for African countries to effectively use higher education human capital in growth policies.*

I. Introduction

> The main engine of growth is the accumulation of human capital – of knowledge – and the main source of differences in living standards among nations is differences in human capital. Physical capital plays an essential but decidedly subsidiary role. (Lucas, 1993; p.270).

This paper investigates the effects of higher education human capital on the growth rate of per capita income in African countries during the 1960–2000 period. We do so by estimating an expanded neoclassical growth equation with higher, secondary and primary education human capital as added repressors. The growth rate of income varies greatly across countries, even in Sub-Saharan Africa where

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the growth record has been nothing but 'tragic'. For example, between 1960 and 2000, aggregate GDP grew at an average annual rate of 1 per cent in Sierra Leone, while it grew at about 10 per cent in Botswana. What explains the large differences in income growth rates among African countries? While investment in physical capital is a source of observed differences in cross-country income growth rates, there could be other equally important sources. Among these are differences in endowments of human capital. Human capital, broadly defined, has several aspects, including education, training, and health. This paper explores the growth effects of one aspect of human capital – higher education human capital.

Modern growth theory suggests that human capital has a positive impact on economic growth. Although there are exceptions, empirical evidence generally shows that human capital has a positive and statistically significant impact on the growth rate of per capita income.[1] For example, Artadi and Sala-i-Martin (2003) argue that if primary school enrolment rates at independence in African countries had been as high as those in OECD countries, the average annual growth rate of per capita income in Africa would have been 2.37 per cent instead of the 0.9 per cent recorded in the last four decades; a growth rate that would have more than doubled per capita GDP over the 40-year period. On the other hand, if African countries had had the same rate of investment in physical capital as OECD countries during the same period, GDP per capita would have grown by 0.44 per cent higher. This additional contribution to the growth rate of per capita income is only 30 per cent of the additional contribution that education would have made to economic growth in Africa. This suggests that education has a much larger impact on economic growth in African countries than physical capital.

While the growth literature suggests that education human capital has a positive impact on the growth rate of income, it is not clear what level of education human capital is positively related to the growth rate of income. Some researchers stress the importance of research and development (hence higher education) as the source of growth (for example, Hall and Jones, 1999; Romer, 1990; Nelson and Phelps, 1966), others argue that primary education is the major source of economic growth, at least in Less Developed Countries (LDCs) (Petrakis and Stamatakis, 2002; McMahon, 2002). If educational attainment in countries increases with the level of income, it will not be surprising that higher education becomes more important for the growth process as income level increases, since higher income countries would have attained universal primary education while LDCs would be increasing both higher and lower levels of education.

There is no doubt that the stock of education human capital in Africa is low compared to the rest of the world. Primary, secondary, and tertiary school enrolments in Africa in 1995 were 51, 39, and 20 per cent respectively of world averages while the average years of schooling in Africa was only 42 per cent of world average; averages that were dramatic improvements over 1965.[2] This rapid improvement was achieved with relatively large investments in education. Between 1970 and 1995, Sub-Saharan African countries, on average, spent 3.7 per cent of GPD and 14.9 per cent of government budgets on education compared to the world averages of 3.35 and 12.6 per cent respectively. Despite these relatively high investments in education, education human capital in Africa remains low. It is

possible that the low stock of education human capital in Africa is due to inefficiency in the educational system and/or the emigration of educated people.

There is a debate as to what level of education deserves more attention in African countries.[3] Based on private and social returns to education, there have been suggestions that African countries should support primary education at the expense of higher education since the social returns to the former are much higher than those of the latter. It is most likely that the growth impact of any level of education will be different from the private returns to education, given that there are externalities associated with education. The debate over the growth impact of primary versus higher levels of education as the driver of growth seem to suggest that these levels of education are substitutes. It is clear that higher education and lower levels of education are not substitutes, but complements. Discussions should therefore focus on increasing the inputs of all levels of education human capital. One of the many ways to evaluate the social impact of higher education human capital is to estimate its impact on the growth rate of per capita income. We focus on the growth impact of higher education without getting into the debate about the relative importance of primary and higher education in the growth process.[4]

Investigating the effects of higher education human capital on income growth has policy implications, especially in African countries where the stock of higher education human capital is so low and its growth effect is likely to be high. In spite of the enormous amount of resources devoted to the provision of higher education in African countries, Africa continues to be endowed with relatively low stocks of higher education human capital partly because of the small base from which it started, partly because of inefficiencies in the production of higher education human capital, and partly because of emigration by educated Africans. If all levels of education are found to contribute to income growth, then more education human capital should be utilised to spur faster economic growth in Africa. Policy efforts should focus on how to efficiently produce more, retain more and productively employ more education human capital at all levels. In spite of the possible contribution of higher education human capital to explaining cross-country differences in income growth, very few empirical studies have been conducted on the effects of higher education human capital on economic growth in African countries. This paper is an attempt to contribute to the literature.

We find that all levels of education human capital have positive and statistically significant impacts on the growth of per capita income in African countries, all things equal. A 1 per cent increase in the average years of higher education human capital increases the growth rate of per capita income by about 0.09 percentage points per year. Although this is likely to be an overestimate, our result suggests that African countries can harness higher education human capital to speed up economic growth. Given that the average growth rate of per capita income in African counties during the sample period was about 0.1 per cent per year, our estimates suggests that per capita income growth rate in African countries can be doubled by raising the supply of higher education human capital to about 0.3 years from the current average of 0.16 years. Our result suggests that increasing higher education human capital in African countries will substantially increase the growth rate of per capita income and hence increase the living standards of people in African countries. The

results are different from those of earlier research that find no significant relationship between higher education and income growth.

The rest of the paper is organised as follows: Section II provides a brief review of previous studies that are pertinent to this paper; Section III presents the growth equation we estimate and dicusses the estimation method; Section IV discusses the data while Section V presents and discusses the statistical results. Section VI concludes the paper.

II. Previous Work

While development economics has always emphasised the importance of education in the development process, it is only recently that growth theory has incorporated education into its analyses. The empirical growth literature has been growing at an exponential rate, hence we cannot review all of it in a short article. We therefore mention a few of the studies that emphasise the importance of education in the growth process. The review will be neither comprehensive nor detailed.

The importance of human capital generally, and of education in particular in growth theory was emphasised only in the 1980s and 1990s by endogenous growth models and the expanded neoclassical growth model of Mankiw, Romer and Weil (MRW). The expanded neoclassical growth model sees human capital as an added input, hence countries that have faster growth rate of education will have faster transition growth rates and higher incomes. Endogenous growth models see education as a process that changes the production technology itself (new products, processes, or knowledge) (Romer, 1990, 1993; Aghion and Howitt, 1998; Nelson and Phelps, 1966), makes it easier to adapt foreign technology (Barro, 1999, 1997; Barro and Sala-i-Martin, 1995; Sala-i-Martin, 1997; Hall and Jones, 1999), or facilitate resource transfer to the most technologically dynamic sector of the economy (Kim and Kim, 2000; Schiff and Wang, 2004). In the endogenous growth literature, education is seen as subject to increasing returns so it could overcome the growth reducing effect of diminishing returns to physical capital (Romer, 1986; Lucas, 1988). It appears that in either endogenous or expanded neoclassical growth model, education should have a positive effect on the growth rate of income. However, it is possible that a minimum level of education is required in order for education to have any measurable growth impact (Azariadis and Drazen, 1990; Rebelo, 1991).

The growth effect of education is an empirical issue, hence we review a few examples of the empirical work on the growth rate of income. Benhabib and Spiegel (1994) concludes that education has no direct effect on economic growth; however, it positively affects economic growth indirectly through technical progress. Some researchers find a positive and statistically significant relationship between male education and income growth, but not for female education or primary education for both genders (Barro, 1997, 1999; Barro and Sala-i-Martin, 1995; Sala-i-Martin, 1997; Caselli et al., 1996). Artadi and Sala-i-Martin (2003) finds a positive relationship between primary school enrolment rates and growth rate of GDP per capita in African countries. MRW (1992) find that education has a positive and statistically significant effect on the growth rate of income in a sample of 88 countries.

Betherlemy, Pissarides, and Varoudakis (2000) find that 40 per cent of educated human capital in a sample of African countries is devoted to rent seeking activities

and this reduces income growth rate by 0.9 percentage points annually. Rogers (2003) finds similar results for rent seeking activities and emigration. This suggests that the growth impact of education partly depends on the proportion of educated people who are productively employed. Pissarides (2000) argues that the growth effect of higher education depends on the growth-enhancing quality of education as well as the efficiency with which labour markets allocate skilled labour to productive activities.

None of the studies mentioned above studies the growth impact of higher education in Africa. McMahon (1987) finds that higher education has a positve effect on income growth, but with a long lag – about seven and half years. Appiah and McMahon (2002) find that education positively affects income growth directly and indirectly, through improved health, the environment, investment in physical capital, reduction in crime rates and political instability. They, however, did not investigate the growth effects of higher education. Agiomirgianaskis, Asteriou and Monasitiriotis (2002) and Voon (2002) find that the higher the level of education (primary, secondary and tertiary), the stronger the growth impact of education, all things equal. Petrakis and Stamatakis (2002) find that the growth effects of education depends on the level of development; low income countries benefit from primary and secondary education while high income developed countries benefit from tertiary education.

III. Econometric Model and Estimation Method

(a) Econometric Model

The approach we use to investigate the effect of higher education on income growth in African countries is to estimate an expanded neoclassical growth equation of the MRW type that uses three levels of education – higher, secondary, and primary – as our measures of human capital. Since this model is well developed elsewhere, we do spend time developing it here but refer the reader to MRW (1992). We make one modification to the MRW model: we include the incidence of civil war as a regressor in the growth equation. Several studies indicate that the incidence of civil war negatively affects the growth rate of income (Gyimah-Brempong and Traynor, 1999; Barro, 1997; Atardi and Sala-i-Martin, 2003 among others). Given the incidence of many civil wars in many African countries during the sample period, it is important that we account for this phenomenon. Institutions are very important for the efficient functioning of an economy. We view the incidence of civil war as the manifestation of weak or inefficient institutions as it affects the availability and utilisation of human capital. This is another reason to include the incidence of civil war as a regressor in the growth equation.

There are several reasons why education would have positive effects on income growth. In endogenous growth models, education can affect economic growth through technical progress either developed domestically or through importation and adaptation of foreign technology to local conditions. Greiner and Semmler (2002) find that there are positive externalities in physical capital investment only when education human capital is available and this explains why some developing countries demonstrate convergence while others do not. Education is also likely to increase the efficiency with which other inputs are used, hence contributing to increases in total

factor productivity (TFT). We note that technical progress, either domestically developed or imported, is not likely to be dependent on primary education, but rather on higher education (Hall and Jones, 1999). Higher education may be a *necessary* but not sufficient condition for income growth. Education is also likely to improve the quality and quantity of other inputs as well as improve the institutional environment in which growth takes place. For example, education improves health and physical capital formation, which are themselves important determinants of economic growth (Nelson and Phelps, 1966; Gyimah-Brempong and Wilson, 2004 among others).

Gradstein and Justman (2002) argue that the impact of education on economic growth is more through its role as a socialising force rather than through technical progress. Education, they argue, reduces the cost of enforcing desirable social norms, lessens the potential for ethnic conflicts in ethnically diverse societies, as well as decrease transaction costs by shrinking *social distance* between individuals in a society. Given the extent of ethnic fractionalisation in African countries, these are likely to be important growth factors in Africa. Appiah and McMahon (2002) make a similar argument as one of the channels through which education affects income growth. It is unlikley that the last two channels of socialisation can be achived through primary or secondary education since these levels of education generally take place at the local level while higher education takes place at the national level and therefore transcends ethnic boundaries.

We note that trying to capture the benefits of education by focusing only on its impact on income growth may not do justice to the benefit of education to society. Although education is likely to affect the productive capacity of the economy directly, it is also likely to have many other social benefits. For example, education may affect the rate of growth and the efficiency of physical capital: increasing human capital could raise the rate of return on physical capital if both are complements. In addition, increased female education has been shown to reduce fertility (Ainsworth, Beegle and Nyamete, 1996), which may free resources in developing countries to increase nutrition and health of children. Improved health itself increases the growth rate of countries (Artidi and Sala-i-Martin, 2003; Gyimah-Brempong and Wilson, 2004).[5] Educating one generation will have beneficial effects on future generations: children are more likely to go to school if their parents are educated. One also has to remember that education may also be a consumption good itself, hence directly influencing the quality of life.

Based on the foregoing, we postulate the aggregate production function, expressed in per capita terms (y), as a function of technology (a), physical capital (k), and human capital (h).[6] Formally, the production function is written as:

$$y = ak^{\alpha}h^{\beta} \tag{1}$$

Taking the natural log of the production function and differentiating the resulting expression with respect to time gives us the growth rate of per capita output as:

$$\dot{y} = \dot{a} + \alpha\dot{k} + \beta\dot{h} \tag{2}$$

where $\dot{y}$, $\dot{a}$, $\dot{k}$, $\dot{h}$ are the growth rates of output, technology, physical and human capital respectively. Human capital has several dimensions. However, we assume

that human capital is directly proportional to educational attainment. Since the growth effects of education are likely to differ by levels of education (Petrakis and Stamatakis, 2002), we proxy h by *higher,* primary (*primary*) and secondary (*secondary*) education. We follow the literature and proxy technology by initial income (y_0) and the sum of population growth, depreciation and technical progress (p).

Based on the discussion above the variant of the MRW growth equation we estimate is:

$$\dot{y} = \alpha_0 + \alpha_1 y_0 + \alpha_2 higher + \alpha_3 secondary + \alpha_4 primary + \alpha_5 k + \alpha_6 p + \alpha_7 civwar + e \tag{3}$$

where $\dot{y}$ is the annual growth rate of real GDP per capita (in constant 1995 US$), *higher, secondary* and *primary* are changes in the stocks of higher, secondary and primary education human capital respectively, p is the sum of average annual population growth rate, depreciation rate and technical progress for a country, y_0 is initial income, *civwar* is the incidence of a civil war in a country, and k is physical capital formation. We proxy part of savings by k, which denotes gross capital formation as a percentage of GDP.[7] In accordance with the empirical growth literature, we expect the coefficients of *higher, secondary, primary,* and k to be positive while those of p and *civwar* are expected to be negative. If conditional convergence operatives in African countries, we expect the coefficient to y_0 to be negative. With the exception of *civwar*, we estimate the equation on the log transforms of all the variables, thus allowing us to intepreter the coefficient estimates as elasticities.

(b) Estimation Method

The regressor of major interest in this paper is higher education human capital (*higher*). However one measures this variables – absolute number of people attaining or enrolled at a certain level of education, or the proportion of the population attaining or enrolled at a given level of higher education, or the average years of educational attainment by the population – education human capital increases with the level of per capita income across countries and through time for a given country (Barro and Lee, 2000). This makes *higher, secondary* and *primary* endogenous regressors.

The growth equation is estimated with data from 34 African countries over the 1960–2000 period. The error term in (3) is a composite error that contains a country specific component η_i, a time component ε_t and an idiosyncratic component v_{it}. The composite error term is given as: $e_{it} = \eta_i + \varepsilon_t + v_{it}$. The unobservable country fixed effects are correlated with the regressors. The possible endogeneity of education as well as the correlation of the unobserved country fixed effects with the error term implies that the orthogonality condition is not likely to be met for random effects (RE) or fixed effects (FE) estimator to produce consistent estimates. One can achieve orthogonality through appropriate differencing of the variables. The equation we estimate contains endogenous as well as the results of lagged endogenous regressors. Therefore, the error terms in the differenced equation are correlated with the

lagged dependent variable through contemporaneous terms in period $t-j$ even if there were no unobserved country fixed effects that are correlated with the regressors.

An instrumental variables (IV) estimator that can account for endogeneity of regressors is therefore needed. An IV estimator that is appropriate for the estimation of growth equations based on panel data is the Dynamic Panel Data estimator developed by Arellano and Bond (1991) as part of their DPD estimator written for GAUSS program. The DPD estimator is a IV General Method of Moments estimator that is equivalent to an efficient Three Stage Least Squares (3SLS) estimator.

The dynamic panel estimator is given as:

$$\hat{\theta} = (\bar{\mathbf{X}}'\mathbf{Z}\mathbf{A_N}\mathbf{Z}'\bar{\mathbf{X}})^{-1}\bar{\mathbf{X}}'\mathbf{Z}\mathbf{A_N}\mathbf{Z}'\bar{\mathbf{y}} \tag{4}$$

where $\hat{\theta}$ is the vector of coefficient estimates on both the endogenous and exogenous regressors, $\bar{\mathbf{X}}$ and $\bar{\mathbf{y}}$ are the vectors of first differences of all the explanatory variables, $\mathbf{Z}$ is the vector of instruments and $\mathbf{A_N}$ is a vector used to weight the instruments. The estimator uses all lagged values of endogenous and predetermined variables as well as current and lagged value of exogenous regressors as instruments in the differenced equation. For example, for the equations: $\Delta y_{i3} = \alpha\Delta y_{i2} + \beta\Delta x_{i3} + \Delta\zeta_{i3}$, we use y_{i1}, x_{i1} and x_{i2} as instruments. For the Δy_{i4} equation, y_{i1}, $y_{12,}$ x_{i1}, x_{i2} and x_{i3} serve as valid instruments. Instruments for other cross sectional equations are constructed similarly. These instruments are correlated with the endogenous regressors, but not correlated with the error terms; hence they are 'good' instruments. Estimates can be obtained for levels, first difference, or orthogonal deviations of the data.[8] Since we are interested in the effects of *changes* in the stock of education human capital on income growth, the first difference estimator is more apprpriate and it is the one we report.

Arellano and Bond proposed two estimators – one- and two-step estimators – with the two-step estimator being the more efficient estimator. In the one-step estimator, the weighting matrix is given by $A_N = (N^{-1}\Sigma_i Z_i' H Z_i)^{-1}$ where H is a $T-2$ square matrix with 2s in the main diagonal, -1s in the first subdiagonal, and zeros everywhere else. The two-step estimator uses $A_N = N^{-1}\Sigma_i Z_i' v_i v_i Z_i$ where v_i is the residual obtained from a preliminary consistent estimate of θ, as the weighting matrix. We report the efficient two-step estimates in this paper.

In estimating the model, we lag all variables by one period to ensure that y_{t-1} can be treated as exogenous in period t. This allows us to use all values of x_t up to x_{t-1} as valid instruments for $\hat{x}_t$. The linear moment restriction implied by the model is $E[(\Delta\tilde{y}_{it} - \Delta\tilde{X}'_{i,t-1}\Theta)X_{i,t-j}] = 0$ for $j = 2, \ldots, t-1$, where $X' = (y_{t-1}, X)$ is the vector of lagged endogenous and strictly exogenous regressors. The consistency of the estimates hinges on lack of autocorrelated errors, hence we test for the absence of serially correlated errors. We also perform Sargan test of over-identifying restrictions, which is a joint test of model specification and appropriateness of the instrument vector. If all regressors are strictly exogenous, both the DPD estimator and FE estimator are consistent but the latter estimator is efficient. On the other hand, if there are endogenous regressors, the FE estimator is inconsistent. Therefore,

we test for the strict exogeneity of all regressors using a Hausman exogeniety test. We included time dummy variables as regressors in all three specifications.

IV. Data

The dependent variable in our model is the growth rate of per capita income ($\dot{y}$). We measure $\dot{y}$ as the annual growth rate of real GDP per capita in 1990 US$. The explanatory variables are investment in physical capital, higher (*higher*), secondary (*secondary*), and primary (*primary*) education human capital, the sum of average growth rate of population, depreciation, and technical progress (p), the incidence of civil war (*civwar*), and initial level of income (y_0). We follow earlier researchers and measure physical capital investment (k) as the investment/GDP ratio in a period. Following MRW, we measure the sum of depreciation and technical progress to be 0.05, hence p is the sum of population growth rate and 0.05. *civwar* is the predicted probability of the incidence of a civil war in a country in a given period. Variables used to predict the probability of civil war incidence are the effectiveness of the legislature (*lege f f ct*), primary export dependency (*primary*), and index of civil liberties (*civ*). y_0 is measured as the real per capita GDP at the beginning of a period. For example y_0 for the 1960–64 period is real per capita GDP for 1960.

Several approaches have been used to measure education in the empirical growth literature. While some researchers use enrolment ratios (for example, Barro, 1999, 1997; Petrakis and Stamatakis, 2002), others use the proportion of the population that has attained a certain level of education (Barro and Sala-i-Martin, 1995); still others use expenditures on education (McMahon, 1987, 2000; Appiah and McMahon, 2002) as the measure of education. Education expenditure/GDP ratio and enrolment ratios appear to have the advantage of being comparable across countries. However, neither enrolment ratio nor expenditure on education is a particularly appealing measure of education when one is interested in the effects of education on economic growth since neither measures education human capital available for productive purposes. It is *additions to the stock* of education human capital that affects economic growth. As Solow (2003) points out, enrolment ratios and expenditures on education are inputs into the production of additional education human capital; they are not additions to the human capital itself. Whether one considers a neoclassical or an endogenous growth framework, what is relevant for production in the current period is education human capital in the current period that is used for production. Hence, what is important for growth is the rate of change of the utilisation of education human capital rather than enrolment rates or expenditures on education. In addition, expenditure on education or enrolment ratios will accurately reflect cross-country (time series) differences in investments in education if there are no cross-country (temporal) differences in efficiency of education production. One also has to worry about reverse causation when using either enrolment ratios or educational expenditure to proxy education human capital in cross-country regressions. Educational attainment on the other hand does not suffer from these weaknesses.

Based on the arguments above, we measure *higher, secondary* and *primary* as the average numbers of years of higher, secondary, and primary education completed by the adult population (25 years or older) in a country in a period.[9] It is possible that

faster economic growth causes increased investment in higher education and hence increases the stock of higher education human capital in subsequent years. To overcome this possible reverse causality, we measure the education variables as the average number of years of education attained by the adult population at the beginning of a period. For example, *higher* for the 1970–74 period is the number of years of higher education in 1970. We note that our measure of education human capital has its own weakness. In particular, we are not able to account for the *quality* and *composition* of higher education human capital or the proportion that is productively employed. Failure to account for these measurement issues could affect the impact of *higher* on economic growth since a part of this human capital is likely to leak out of Africa through emigration. Our results should therefore be interpreted with this measurement problem in mind.

Data on most of the economic variables ($\dot{y}$, y_0, k, *popgrow*) were obtained from the World Bank's *World Development Indicators, 2001* (Washington, DC: World Bank, 2001) and were for the years 1960 to 2000. Data for *civwar* were obtained from Singer's *Correlates of War Project: Internal War Data, 1816–1998*, ICPSR 09905 (University of Michigan; Ann Arbor, Michigan). Data on *lege f f ct*, and *civ* were obtained from Robert Bates' African Research Project at Harvard University, downloaded from the Project's website at http://www/gov.harvard.edu/research.bates. Data for education (*higher, secondary, primary*) were obtained from Barro and Lee (2000), *Human Capital Updated Files* downloaded from the Centre for International Development website at http://www.cid.harvard.edu/ciddata/ciddate.html.

The data are for 34 African countries over the 1960–2000 period.[10] We follow the usual practice in the empirical growth literature by taking five-year averages of the variables. This approach potentially gives us 340 observations. However, we did not have data on all variables for all countries for all years, hence we had an unbalanced panel of 186 observations for estimating the growth equation. Summary statistics of the sample data are presented in Table 1. It is clear that the growth rate of per capita GDP was very low during the sample period; as compared to those of other parts of the developing world, population growth rate was very high, education human

Table 1. Summary statistics of sample data

Variable	Label	Mean*	Std. dev	Minimum	Maximum
GDP growth rate (%)	$\dot{y}$	0.1023	2.2109	−2.6029	3.4317
Investment/GDP (%)	k	21. 5721	30.1709	0.0001	73.1000
Higher education (years)	*higher*	0.167	0.127	0.0013	0.213
Initial income (1990 US$)	y_0	853.96	1178.27	58.00	8510.31
Civil war	*civwar*	0.123	–	0.00	1.00
Population growth	*popgro*	2.629	0.1061	1.3593	3.5348
Technical progress	p^+	2.679	0.1061	1.4093	3.5848
Secondary education (years)	*secondary*	2.2500	1.8925	0.0953	4.5580
Primary education (years)	*primary*	4.0420	0.8231	1.6094	4.9930
N	186				

Note: *These are unweighted averages.
^+p is the sum of population growth rate and 0.05.

capital very low, and the level of per capita income very low. The summary statistics confirm the observation by Easterly and Levine (1997) and Atardi ans Sala-i-Martin (2003) that Africa's growth record, thus far, has been nothing but tragic.

V. Results

(a) Statistical Results

GMM coefficient estimates of the growth equation are presented in Table 2. Column 3 presents the DPD estimates for the full model while column 2 presents FE estimates for the purposes of comparison. The regression statistics for the DPD estimates indicate that the model is well specified and fits the data relatively well. In particular, there is no first order serial correlation at $\alpha = .01$ and the Sargan test statistic, which is a joint test of identification and model specification, indicates that the model is well specified with the appropriate instrument vector. The Hausman test statistic rejects the null hypothesis that all regressors are exogenous, all coefficient estimates have the expected signs, and most of them are significantly different from zero at $\alpha = .05$ or better. However, this is not the case for the FE estimates presented in column 2. In particular, all coefficient estimates of the education variables are not significant and the coefficient of *higher* has the wrong sign. The Hausman exogeniety test statistic also rejects the null hypothesis that all regressors are exogenous at any reasonable degree of confidence. Thus, the DPD estimator, rather than the FE estimator, is the appropriate estimator for the growth equation. Therefore, all discussions of the results in this paper will be based on the DPD estimates.

We now discuss the estimates of the full model presented in column 3. The coefficient of p is negative but insignificant, while the coefficients on all time dummies are negative and statistically significant at $\alpha = .05$ or better. Wald statistic to test the null hypothesis that all time dummy coefficients are jointly equal to zero rejects the null at $\alpha = .01$. The estimated coefficients on the time dummies are consistent with the observation that income growth rates in African countries declined during the sample period. The coefficient of k is positive and significantly different from zero at $\alpha = .01$ with estimated growth elasticity of about 0.04. This coefficient estimate suggests that investment in physical capital has a statistically significant positive impact on the growth rate of per capita income in African counties, all things equal.

The coefficient of y_0 is negative and significant at $\alpha = .01$ in all specifications, suggesting the existence of conditional convergence in African countries. The coefficient of *civwar* is negative, relatively large, and significantly different from zero at $\alpha = .01$, suggesting that the incidence of civil war has a very large and statistically significant negative impact on the growth rate of per capita income in African countries. These results are consistent with the results of earlier researchers who find positive relationship between the growth rate of per capita income and investment rate (Barro, 1997; Barro and Sala-i-Martin, 1995; Caselli et al., 1996; MRW, 1992; Temple, 1999, among others) and a negative relationship between economic growth and civil war incidence (Gyimah-Brempong and Traynor, 1999; Barro, 1997; Appiah and McMahon, 2002, among others).

The coefficient of *higher* is positive, relatively large and significantly different from zero at $\alpha = .01$ or better. The elasticity of income growth with respect to *higher* is

Table 2. GMM estimates of growth rate equation

Variable	Coefficient			Estimates	
	FE	Full model	IV	Only *higher*	No *higher*
p	0.0618	− 0.0042	− 0.0061	− 0.0039	− 0.0178
	(0.8297)$^{+}$	(1.2713)	(1.3861)	(0.7713)	(0.8348)
k	0.1451**	0.0439***	0.0336**	0.0329**	0.0394***
	(2.1889)	(3.9650)	(3.5359)	(3.6677)	(2.8917)
higher	−0.0299	0.1179***	0.0899***	0.1281***	–
	(1.4897)	(4.0862)	(3.2178)	(4.2932)	
y_0	−0.0051***	−0.0045***	−0.0072**	−0.0045***	−0.0038**
	(2.4872)	(3.5799)	(1.7983)	(4.5799)	(1.9941)
civwar	−9.4612***	−6.9821***	−5.0351***	−6.8597***	−8.2148**
	(4.8316)	(6.4218)	(3.0582)	(6.9218)	(4.2146)
primary	0.0092***	0.0814**	–	–	0.0181**
	(2.6784)	(2.6656)			(2.2269)
secondary	0.0062*	0.0571**	–	–	0.0612**
	(1.7928)	(2.2077)			(2.0082)
*TimeD*1	0.0024**	−0.0271**	−0.0116*	−0.0227***	−0.0179*
	(1.8964)	(2.2894)	(1.6786)	(2.6286)	(1.7184)
*TimeD*2	−0.0026*	−0.0435***	−0.0098***	−0.0441***	−0.0334***
	(1.6833)	(5.7036)	(3.9006)	(4.8613)	(4.0593)
*TimeD*3	−0.1529	−0.0295***	−0.0241***	−0.0265***	−0.0248***
	(1.4929)	(5.5164)	(5.2372)	(3.5593)	(3.1519)
*TimeD*4	−0.0422***	−0.0402***	−0.0382***	−0.0401***	−0.0406***
	(3.9826)	(2.3491)	(4.2871)	(5.8137)	(3.9836)
*TimeD*5	−0.0211**	−0.0183**	−0.0079**	−0.0208***	−0.0104
	(2.316)	(2.3896)	(2.1192)	(2.8681)	(1.4679)

(*continued*)

Table 2. (*Continued*)

Variable	FE	Coefficient Full model	IV	Estimates Only *higher*	Estimates No *higher*
1st-order ser. cor.	2.8921 [23]	0.452 [23]	0.9286 [23]	1.256 [23]	1.3972 [23]
2nd-order ser. cor.	1.8975 [21]	−0.562 [21]	−0.4381 [21]	0.174 [21]	0.5821 [21]
Jt. test of Sig.		152.0207 [7]	129.8721 [5]	108.836 [5]	198.5818 [6]
Sargan Test		13.3059 [14]	15.3981 [16]	15.495 [16]	11.9505 [14]
Hausman m	89.5971 [7]	81.716 [7]	78.2198 [5]	80.913 [5]	88.8762 [6]
Jt. Sig. Test Time	487.643 [6]	438.186 [6]	2897.5137 [6]	805.106 [5]	400.5181 [6]
Wald Test^{++}	48.3972 [3]	78.0209 [3]	59.9281 [1]	37.3182	48.5621 [2]
F	48.2817				
$\bar{R}^2$	.4363				

Note: $^{+}$absolute value of asymptotic 't' statistics calculated from heteroskedastic consistent standard errors in parentheses. *2-tail significance at $\alpha = .01$. **2-tail significance at $\alpha = .05$. ***2-tail significance at $\alpha = .01$. $^{++}$Wald test for joint significance of *higher*, *secondary* and *primary*.

about 0.12, an estimate that is about three times as large as that of physical capital investment. The coefficients of *primary* and *secondary* are positive and significantly different from zero at $\alpha = .05$ or better, indicating that primary and secondary education have positive and statistically significant effects on the growth rate of per capita income. The coefficient estimates are 0.08 and 0.06 for *primary* and *secondary* respectively. These coefficient estimates are similar in magnitude to those estimated by researchers who find positive relationship between education and growth (McMahon, 1987; Appiah and McMahon, 2002; Agiomirgianaskis, Asteriou and Monasitiriotis, 2002; Voon, 2001; Atardi and Sala-i-Martin, 2003). The estimates are different from those of researchers who find no significant relationship between education for both genders and income growth even though they find significant relationship between income growth and male education (Barro, 1997, 1999; Barro and Lee, 1994; Barro and Sala-i-Martin, 1995; Pritchett, 2001). This estimate suggests that higher education human capital may be more important for growth in African countries than physical capital investment. Perhaps, this relatively large growth impact of higher education human capital stems from the fact that Africa has very low stocks of higher education human capital, making its marginal contribution to income growth relatively large.

It is possible that our results overestimate the effects of higher education while underestimating those of primary and secondary education on economic growth even though the equation includes primary and secondary education human capital as regressors. Any person who has achieved any level of higher education also has attained some years of primary and secondary education. By definition, our measure of higher education includes lower levels of education, hence the coefficient of *higher* overstate the growth effects of higher education. This implies that *higher* contains elements of secondary and primary. The inclusion of *primary* and *secondary* as regressors does not correct for this problem.[11] One way we experimented to deal with this problem is to use *primary* and *secondary* as instruments for *higher*.[12] The R^2 from the first stage regression is 0.6167, suggesting that primary and secondary education are 'good' instruments for higher education. Since this measure of higher education is a predicted value, we use Murphy and Topel's (1985) approach to calculate the variance–covariance matrix of the coefficient estimates.[13]

The IV estimates are presented in column 4. The coefficients of p, k, y_0, *civwar*, and the time dummies are similar to those in column 3. With the exception of p, all are statistically significant at $\alpha = .10$ or better. The coefficient of *higher* in column 4 is positive and significantly different from zero at $\alpha = .01$ with estimated growth elasticity of about 0.09. This suggests that using *primary* and *secondary* to instrument for *higher* in estimating the income growth equation does not *qualitatively* change our result that higher education human capital has a significantly positive effect on income growth in African countries. However, there is a *quantitative* change in the coefficient of *higher*; there is a 24 per cent reduction in the absolute magnitude of the coefficient of *higher*.

This is an indication that the coefficient of *higher* in column 3 may overstate the growth effect of higher education in African countries. The degree to which the coefficient of *higher* overestates the growth effect of higher education is not precisely known. We explore this by estimating the growth equation without *primary* and

secondary as regressors. The change in the coefficient of *higher* in this regression may provide an indication of the direction and size of the bias. The estimates are presented in column 5. The coefficient of *higher* in this equation increases to about 0.13. Comparison of the coefficient of *higher* in columns 3–5 suggests that the coefficient of *higher* may overestimate growth impact of higher education by between 24 to 40 per cent.

How important is *higher* in the growth rate equation in African countries? We estimate the growth equation without *higher* and compare the estimates with those of the full equation. The coefficients on *primary* and *secondary* in this equation may also give an indication of how much *higher* leads to an understimate of the growth impact of primary and secondary education. Coefficient estimates of this equation are presented in column 6. Regression statistics indicate that the estimates are satisfactory. The coefficient estimates are of the expected signs, similar to their counterparts in the full model, and are significantly different from zero at conventional levels. The coefficients in column 6 are less precisely estimated than their counterparts in the full equation. The coefficients of *primary* and *secondary* are much higher in column 6 than those in column 3, providing another indication that *higher* may overstate the growth impact of higher education while underestimating those of primary and secondary education. In addition, a Hausman test to test the equality of the coefficients in the full equation and the truncated equation produced a X^2 statistic of 66.281. With 11 degrees of freedom, we reject the null of equality between the two sets of estimates. This excercise sugests that excluding *higher* from the income growth equation may cause the usual omitted variable bias problem.

The estimates of the growth effects of education, especially higher education, are large, statistically significant, and suggest that all levels of education have positive effects on income growth in African countries. How do our estimates compare with those of other researchers? Portela et al. (2003) summarised the most recent estimates of the effects of education on growth. The paper suggests that the average effect of education on growth ranges from 0.065 to 0.080 for the average five-year period; the effect increases with time. Our estimate is at the upper end of this average. Our estimate is also similar to that of Agiomirgianaskis et al. (2002) who find that the growth impact of education human capital increases with the level of education. For studies that focus on Africa, McMahon (1987) estimate the growth effects of higher education at 0.075, but this happens with a very long lag while Bethelemy et al. (2000) find that rent seeking decreases the effect of education on growth.

Our results differ from those of a large number of researchers who find no significant or negative relationship between higher education and economic growth (Barro, 1999; Barro and Lee, 1994; Barro and Sala-i-Martin, 1995; Caselli et al., 1996; Pritchett, 2001). Rogers (2003) and Beine et al. (2001) argue that the reason some researchers find no relationship between education human capital and economic growth is that they do not account for employment in rent seeking activities or emigration of educated people. Once one accounts for these, there is a strong, positive relationship between all levels of education and income growth. Our results, based on educational attainments, are consistent with this interpretation of the data since we control for some of the factors that cause emigration – the incidence of civil war – in our estimation. On the other hand, studies that use

enrolment ratios and expenditure ratios cannot account for the effect of emigration. Our results show how important higher education could be for income growth in Africa, conditional on graduates staying and working in Africa.

Barro and Sala-i-Martin (1995) suggest that when initial human capital/physical capital ratio is greater than the optimal ratio, economic growth rate increases with this imbalance. On the other hand if the initial ratio is less than the optimal ratio, economic growth rates decrease with the imbalance. Countries are therefore less likely to recover from a shortage of human capital than they are likely to recover from shortage of physical capital. Our result is consistent with this observation. Low initial higher education human capital in African countries may imply that the human capital/physical capital ratio was below the optimal ratio, thus decreasing Africa's growth performance. This may also explain why Africa has not been able to recover from the economic shocks of the 1970s. It is interesting to note that Africa's economic stagnation has coincided with the period of a massive 'brain drain' to the developed world or to more affluent parts of the developing world.

(b) Discussion

What are the implications of our results for educational policy in Africa? The results suggest that increased education human capital at all levels, including higher education, has significantly positive impacts on the growth rate of per capita income in African countries. This result is different from the results of research that find negative or or no significant relationship between higher education and income growth. The result suggest that African countries can increase their income growth by adding to their stock of higher education human capital. How can African countries achieve this, given their current resource constraints? Shifting resources from lower levels of education to fund higher education is not likely to be an optimal policy given the fact that lower levels of education in Africa are already under-resourced. Besides, any effective and efficient higher educational system is only possible with strong and effective lower levels of education. It may also not be possible for African countries to drastically increase resources to the education sector, at least in the short to medium run, given the dire fiscal situation most face.

One way to increase the supply of higher education human capital stock in the short run is to improve the efficiency of providing higher education. There is evidence of extreme inefficiency in the higher education sub-sector in African countries. While average per student expenditure in post-secondary education in developed countries is approximately twice that of primary education, it is about six to 10 times in African countries (Keller, 2004; McMahon, 2000). There is therefore more room for providing more higher education without additional resources. Second, given the high reported private rates of return to higher education in African countries, especially for emigrants, another way to increase the supply of higher education human capital is for students to finance their education through *effective* loan schemes. A third policy option is to increase cost recovery from the beneficiaries of government expenditure on higher education, given the reported high private rates of returns and the high rates of emigration of higher education graduates. Finally, it may be necessary to encourage the private sector to become providers of higher education, a process that a few African countries have started to embrace.

Since attaining independence in the 1960s, African countries have spent relatively large proportions of national resources on the provision of higher education, producing some high calibre graduates. However, a large proportion of this higher education human capital emigrate to developed countries.[14] Beine et al. (2001) show that emigration has a detrimental effect on an economy when the 'brain drain' effect exceeds the 'skill acquisition' effect. This occurs when the economy is 'open' and the wage differential between the rest of the world and that economy is large – conditions African countries find themselves in. Our result suggests that higher education human capital contributes significantly to income growth in Africa if it does not leak out through emigration. This has important policy implications.

A policy implication of this argument is that since the private returns to higher education far exceed the social returns, African countries should not be in the business of subsidising higher education if they cannot ensure that graduates will stay in Africa to help in the development process. The high rate of emigration of educated Africans may suggest some malfunctioning of economic and social institutions. African countries should take steps to stem the tide of this massive brain drain they continue to suffer. Examples of such policies are tying university funding to the proportion of graduates who worked in the country, selecting people to study abroad from only those who are currently employed in the country and holding their positions for them, forgiving or reducing student loans for graduates who do not emigrate, and ensuring meritocracy in a transparent way in job markets. In addition, African governments should make a concerted effort to attract the expertise of these emigres back home to help in the development process. There are indications that African policy makers recognise this and are beginning to make efforts to attract the energies of the African diaspora.

Although the estimated growth effect of higher education human capital in Africa we find in this paper is likely to be an overestimate, there is another sense in which the estimate may be a lower bound. There are a number of indirect channels through which higher education could affect the growth rate of per capita income that we do not investigate in this paper. Among these are: improvement in health; reduction of social distance; reduction of ethnic conflicts and civil wars; and increasing political stability. In African countries with heterogeneous ethnic and religious groupings and a lack of well-established national identities, informal ties developed through higher education could be extremely important for national stability, hence economic growth. Finally, higher education is likely to lead to improved performance of institutions that enhance economic growth.

VI. Conclusion

This paper used panel data from a sample of African countries for the 1960–2000 period and a dynamic panel estimator to investigate the effect of higher education human capital on the growth rate of per capita income in African countries. Using the augmented neoclassical growth model of Mankiw, Romer and Weil (1992), we find that higher education human capital has a relatively large and statistically significant effect on the growth rate of per capita income. We find the growth elasticity of higher education human capital of about 0.09 is about three times as large as the growth impact of physical capital investment. This may imply that the

reliance on increased physical capital investment as the way to increase the growth of income in African countries may be misplaced. The result is also robust to the inclusion of primary and secondary education as regressors in the growth equation. We note that our estimate of the growth impact of higher education is likely to be an over-estimate because we are not able to completely disentagle growth effects of lower levels of education from that of higher education. We are also not able to account for 'growth loss' due to the emigration of highly educated Africans. Our results are different from the results of researchers who find no significant relationship between higher education and economic growth.

There are both research and policy implications flowing from our results. Given the differential marginal impacts of higher and lower levels of education human capital, it may be necessary for researchers to disaggregate education into different levels in order to be able identify the true effects of different levels of education on economic growth. Using one aggregate measure of education is likely to cause the usual aggregation bias. Besides disagregating education will provide better guidance to policy makers since it can give an indication as to which level of education to emphasise in policy formulation. African countries have spent relatively large proportions of national resources on the provision of higher education, producing relatively large stock of high calibre graduates. However, a large proportion of this higher education human capital is lost to African countries through emigration. Our result suggests that African countries should take steps to stem the tide of this massive 'brain drain' they continue to suffer. In addition, they should make a concerted effort to attract the expertise of these emigres back home to help in the development process. There are indications that African policy makers recognise this and are beginning to make efforts to attract the energies of those in the African diaspora.

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Notes

1. See Temple (1999) for an excellent review of the modern growth literature.
2. UNESCO, various years *Global Educational Digest*, Montreal: UNESCO Institute for Statistics.
3. See Pissarides (2000) for an excellent summary of some of these studies.
4. Although the debate over the relative importance of various levels of education is important, it is not the focus of this paper, hence we do not get into that debate in this paper.
5. Kalemli-Ozcam (2003) argues that the causation is from health to education rather than the other way round. Regardless of the direction of causation, education (both quality and quantity) and health are significantly correlated.

6. For simplicity, we make no distinction between output per capita and output per worker.
7. The other component of savings include the acquisition of human capital.
8. Orthogonal deviations expresses each observation as the deviation from the average of future observations in the sample for the same country, and weight each deviation to standardise the variance. Formally, the orthogonal deviation of the variable x (x_{it}^*)is given as:

$$x_{it}^* = \left(x_{it} - \frac{x_{i,t+1} + \cdots\cdots + x_{i,}}{T-t}\right)\left(\frac{T-t}{T-t+1}\right)^{.5} \quad \text{for t} = 1, \ldots, \text{T} - 1 \tag{5}$$

   Arellano and Bond show that if the original errors are uncorrelated and homoskedastic, the transformed errors will also be uncorrelated and homoskedastic.
9. Because we use the first difference estimator based on the logs of the variables, the differenced variables reflect the growth rates of these variables.
10. The countries in the sample are Algeria, Angola, Benin, Botswana, Burundi, Cameroon, Central African Republic, Congo, Egypt, Gambia, Ghana, Guinea-Bissau, Kenya, Lesotho, Liberia, Malawi, Mali, Mauritania, Mauritius, Mozambique, Niger, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Zaire (DRC), Zambia, and Zimbabwe.
11. Suppose one needs a fixed number of years ω of lower level education to enter a higher education institution. Suppose the higher education equivalent of this lower level of education is inversely proportional to the years of higher education attained (X). Finally suppose that one only observes the years of higher education but not the net addition to education that is relevant for growth. This means that observed average years of higher education, X consists of net years of higher education X^* plus higher education equivalent of lower levels of education (ω) or $X^* = X - \omega/X$. Substituting X^* into (1), the net growth impact of higher education is overestimated by $\alpha_2 * \omega/X^2$.
12. We note however that secondary and primary education have growth impacts of their own they are not classic instruments since they are likely to be correlated with the error term of income growth rate.
13. See Murphy K. and Topel, R. (1985) 'Estimation and Inference in Two-Step Econometric (Models', *Journal of Business and Economic Statistics*, Vol.3, No.4, pp.370–379.
14. The effects of emigration on the loss of higher education human capital to African countries is likely to exceed what the numbers indicate. Generally, the emigrants are likely to be the most capable, productive, and energetic who are most likely to succeed in an internationally competitive labour market. These are the ones who may contribute the most to African economic growth.

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