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THE ECONOMIC IMPORTANCE OF EDUCATION: EVIDENCE FROM AFRICA USING DYNAMIC PANEL DATA ANALYSIS

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The existing literature has dealt inadequately with the link between education and economic growth in developing countries, particularly for Africa which has experienced a massive growth of enrolment at all levels of education during the second half of the 20th century. Moreover, the issues of causality and dynamics have been largely ignored until lately. This paper investigates the empirical link between education and economic performance for the case of 40 African States for the time period 1980-2000 using both static and dynamic panel data analysis. Result from the analysis shows that education has been an instrumental element in the growth process, though to a lesser extent as compared to recent empirical works. The study also confirms the presence of dynamics in the education-growth debate and is in line with recent findings from other developing country cases.

JEL classification codes: C23, I20, O11
Key words: education, economic development, GMM

I. Introduction

It was not until the early 1990's that economists began to place greater emphasis on the role of human capital as a determinant of productivity and growth. Since then the importance of human capital and education in economic development has received much attention and a strong consensus has emerged in the last decade that human capital accumulation is an important determinant of economic growth. However, until now most academic works have been based on cross country data and have overwhelmingly focused on developed countries cases (see Griliches 1997; Temple 2001 and Sianesi and Van Reenen 2003 for comprehensive surveys). Studies on the education-growth link for developing countries have been scarce

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and we have not come across any rigorous panel data analysis based exclusively on a sample of African economies. Very importantly as well, the reverse effect from growth to education, and thus the possibility of endogeneity has been largely ignored in the literature until recently.

African countries present an interesting case study as they remain among the least developed countries and there is growing interest around the world to help the continent out of poverty and to foster its growth. Moreover, Africa experienced a massive growth of enrolment at all levels of education during the second half of the 20th century, especially since the 1970s. In fact, on average for Sub-Saharan Africa, gross enrolment rates at the primary level doubled from 40% in 1960 to almost 80% in 1995, with secondary level increasing eightfold, from 3.4% to 27%, during the same period (World Bank, 1999 *Annual Report*). The growth of education for females was even more impressive than for males and remains one of the highest worldwide (Sender 1999). Has this phenomenal growth in education in this continent translated into higher growth prospects? This question has remained largely unanswered.

This study aims thus at analysing the growth impact of education for a panel of 40 African countries.[1] It uses two models, namely, a Cobb-Douglas production function and a growth equation with a number of determinants selected from the literature. Data availability being an important constraint for developing countries, particularly for Africa, the time span of study is for the periods 1980-2000 and 1985-2000 respectively. A static random effects panel data regression technique is employed in the first instance and the paper further uses dynamic panel data techniques, namely the Generalised Methods of Moments (GMM) method to account for the possibility of dynamics and endogeneity issues. The latter has largely been ignored in the literature. Empirical findings from these economies may add new insights to the debate, particularly from a policy view point, and also supplement the existing body of literature. The rest of the paper is organized as follows

Section II briefly discusses the theoretical underpinnings and empirical literature on the education-growth link. Section III presents an overview of the state of education in Africa. Section IV deals with the model specification, data collection and investigates the hypothesised empirical link for the case of the African sample. Section V concludes and deals with some policy implications.

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[1]Algeria, Angola, Benin, Botswana, Burundi, Burkina Faso, Cameroon , Cape Verde, Congo, Chad, Central Africa, Cote D'Ivoire, Gabon, Gambia, Ghana, Egypt**,** Ethopia, Kenya, Lesotho, Madagascar, Mozambique, Mauritania, Mauritius, Malawi, Mali, Morroco, Namibia, Niger, Nigeria, Rwanda, Senegal, Seychelles, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe.

II. Literature review

Education stimulates economic growth and improves people's lives through many channels, namely: by increasing the efficiency of the labor force and thus increasing an individual's earning potential, by fostering democracy (Barro 1998) and thus creating better conditions for good governance, by improving health and reducing fertility, by enhancing equality (Aghion, Caroli and García-Peñalosa 1999), and so on. Education, in fact, produces a "ripple effect" throughout the economy by way of a series of positive externalities. For instance Michaelowa (2000) argues that educated persons, as well as of those who indirectly learn from them, benefit from increased earnings and this can be interpreted as a reflection of productivity gains. Moreover, the wage differential reflects the higher value of human capital which, being an input factor in the national production function, contributes to an increased national output. Education is also seen to positively influence another dimension of human capital, with similar consequences for increased productivity and growth through its impact on health. Education also leads to reduced birth rates through its impact on reduced population growth. From a statistical point of view this increases national income and growth on a per capita basis. In addition it is clear that the number of childbirths affects women's physical ability to work and their productivity. Finally, education has often been argued to induce more persons to participate in the labor force. This might in turn lead to a reallocation of the population towards economically more productive activities and ultimately have an impact on growth.

A. Micro level evidence

Direct private returns to education

The most commonly used approach on the link between education and increased individual earnings is based on some variant of the Mincerian earnings function (Mincer 1974). The natural logarithm of wages is regressed on years of schooling, a proxy of labor market experience, its square, and on a variety of control variables (Temple 2000). Psacharopoulos (1994) provides an overview of the results of the extensive literature in this field using the basic Mincerian framework described above. He suggests that there are overall positive effect of additional education. He further observes that the rates of return to education are higher for primary education, than for further education, and that primary education contributes more to economic growth in less developed countries than in developed countries. Appleton, Hoddinott

and Mackinnon (1996), for the case of sub-Saharan Africa, however find that the average (private) returns to education suggested by their survey are substantially below those presented in Psacharopoulos (1994). Knight and Sabot (1990) and Behrman, Rosenzweig and Taubman (1996) confirm the positive relationship. Other authors aimed at isolating the causal impact on individual wages of the average level of education of all individuals in an attempt to identify externalities from education. Moretti (1999) and Acemoglu and Angrist (1999) generally suggested a positive relationship between private returns to education and average schooling. The above methodological technique, however, suffers from serious endogeneity problems (see Sianesi and Van Reenen 2003).

Unfortunately, as Schultz (1996) says, "only few African countries have sufficient data on wage structures over a long period of time to empirically analyze the trends in the returns to education". Among the rare studies features Schultz (1996) for Ghana and Cote D'Ivoire, and Glewwe (1996) for the case of Ghana.

Externalities and other indirect effects

Besides the direct effect of education on earnings, it can be observed that education influences other variables, which again have an impact on private income. These indirect links particularly concerns externalities within the family where education of the parents, in particular of mothers, was consistently shown to be a significant factor improving children's health and education. Evidences are available from Cochrane, Leslie and O'Hara (1980) and Glewwe (1999). Besides the effect on children's health, many authors also report an effect of education on fertility (see Schultz 1988 and Behrman 1990). Thus education leads to more informed decisions with respect to health and hygiene, and to a reduced number of childbirths.

B. Evidence at the macro level

Growth accounting

Most macro level research in the area has stemmed either from growth accounting or growth regression frameworks and has been based on the US and other OECD countries mainly. Growth accounting essentially divides output growth into a component that can be explained by input growth, and a "residual" which captures efficiency change, partly reflecting changes in technology. This principle can be extended to any number of inputs, in our case educational attainment. This method

allows the researcher to quantify the proportion of output growth that can be directly attributed to increases in educational attainment. As far as the growth accounting framework is concerned, a number of well known studies have reported a positive contribution of education to economic growth, for instance, Jorgenson, Gallop and Fraumeni (1987), Englander and Gurney (1994), Young (1995), Klenow and Rodriguez-Clare (1997) and Kruger and Lindahl (2001). However, other authors (Benhabib and Spiegel 1994) have also noted that differences in educational attainment appear to explain only a small amount (or not at all) of the difference in output per worker. In reviewing the evidence as a whole, Griliches (1997) argues that increases in educational attainment seem to have accounted for perhaps a third of the productivity residual in the US over the post-war period.

Growth regressions/macro regressions

Although growth accounting exercises are informative and often useful, they have often been criticized for their restrictive assumptions. The "new growth evidence" exploits cross-country variation in the data to estimate and does not impose the parameters of the aggregate production function. In these regressions, sometimes termed "Barro regressions", the choice of explanatory variables is largely driven by previous results in the literature. In fact, the aim of such macro regressions is to investigate the respective role of the various "inputs" in contributing to economic growth. The key attraction of growth regressions is that they provide a way of testing directly for productivity effects of education.

One of the best known and most influential contributions to the empirical growth literature, including the growth effects of human capital, is that of Mankiw, Romer, and Weil (1992), who confirmed earlier results from Barro (1991) in establishing the macroeconomic importance of education. The positive association between education and economic growth has also been reported by a number of authors, for instance, Levine and Renelt (1992), Gemmell (1996), Barro and Lee (1993), Judson (1998), Krueger and Lindahl (2001), and more recent studies from Bassanini and Scarpetta (2001), Andreosso-O'Callaghan (2002) and Baldacci et al. (2004). In contrast, however, several well-known studies have also found the correlation between human capital and growth to be surprisingly weak, yielding very small pay-offs and even negative at times. Such studies include Knight, Loayza and Villanueva (1993), Benhabib and Spiegel (1994), Islam (1995), Caselli, Esquivel and Lefort (1996), Pritchett (1996), Temple (2001) and Bils and Klenow (2000).

The level and the growth rate

Pritchett (1996) argues that "if an individual's education contributes directly to their productivity, in the manner envisaged by labour economists, we should expect to observe a correlation between the change in output per worker and the change in average educational attainment, at least after controlling for other variables". This argument has shifted the focus of research towards regressions that relate growth to the change in educational attainment, rather than its level. In fact, within the empirical literature there is much, and in some sense unresolved debate. Several well-known studies find the relationship between changes in educational levels and growth rates to be surprisingly weak, for instance Romer (1994), Benhabib and Spiegel (1994) and Pritchett (1996) come to this conclusion for a large sample of countries. Some recent contributions, however, show that this result may be biased by measurement error (Krueger and Lindahl 2001), or dependent upon the particular study. On the other hand, Engelbrecht (1997) also finds significant effects for both the level and growth of education on OECD economic growth. A comprehensive summary table of the macro related empirical evidences is shown below.

Table 1. Summary table on related macro-economic empirical studies

Study	Variable used and methodology	Estimated coefficient and interpretation
Growth accounting		
Jorgenson, Gallop and Fraumeni (1987)	• Investment in human and physical capital • Growth accounting methodology used in the growth of (a) the education sector, (b) the non-education sectors and (c) a new measure of the US economy	• Investment in education and physical capital accounts for an overwhelming proportion of the growth of the US economy during the post-war period
Englander and Gurney (1994)	• Secondary enrolment rate and productivity growth in G7 countries	• A percentage point increase in secondary enrolment rate is associated with around a 1.5 percentage point increase in productivity growth
Young (1995)	• Schooling years and the annual growth rate of effective labour • post-war growth performance of four East Asian economies (Hong Kong, Singapore, South Korea and Taiwan)	• Improving schooling years of the workforce raised the annual growth rate of effective labour input by about one percentage point

Table 1. (continued) Summary table on related macro-economic empirical studies

Study	Variable used and methodology	Estimated coefficient and interpretation
Growth accounting		
Griliches (1997)	• Comprehensive survey in growth accounting	• Increases in educational attainment seem to have accounted for perhaps a third of the productivity residual in the US over the post-war period
Benhabib and Spiegel (1994)	• Cross-country estimates of physical and human capital stocks • Growth accounting regressions implied by a Cobb-Douglas aggregate production function • Analyses both levels and growth effects	• Human capital growth has an insignificant, and generally negative impact on per capita income growth • Human capital levels positively affect per capita income growth, and play an important role in attracting, or stimulating, physical capital accumulation• Human capital levels positively affect per capita income growth, and play an important role in attracting, or stimulating, physical capital accumulation
Klenow and Rodriguez-Clare (1997)	• Barro-Lee level of schooling of the adult population (aged 25 and over) • Decompose differences in output per worker across 98 countries	• Shows the importance of total factor productivity vs. physical and human capital inputs in explaining international differences in levels and growth of output
Krueger and Lindahl (2001)	• Schooling years and change in the log of GDP per capita in up to 108 countries	• Growth of education affects GDP growth • Important growth effects
Growth regressions		
Barro (1991)	• Primary (secondary) enrolment ratio and per capita GDP growth rate • 98 countries in the period 1960-1985	• A 1 percentage point increase in primary (secondary) enrolment ratio is associated with a 2.5 (3) percentage points increase in per capita GDP growth rate
Mankiw, Romer, and Weil (1992)	• GDP per working age person and human capital as the average percentage of working age population in secondary school • Cross-sectional framework, 98 countries	• A 1 percent increase in the average percentage of working age population in secondary school is associated with a 0.7 percent increase in GDP per working age person
Levine and Renelt (1992)	• Secondary school enrolment rate and real GDP growth rate • 119 countries, 1960-1989	• A positive relationship whereby a 1 percentage point increase in secondary school enrolment rate is linked with between 2.5 to 3.7 percentage points increase in per capita income

Table 1. (continued) Summary table on related macro-economic empirical studies

Study	Variable used and methodology	Estimated coefficient and interpretation
Growth regressions		
Barro and Lee (1993)	• The level of schooling of the adult population (aged 25 and over) and real GDP • Panel data (random effects) estimation using Seemingly Unrelated Regressions (SUR) and Instrumental Variables (IV)	• One additional year of male secondary schooling raises a country's rate of growth by 1.4 percentage points • One additional year of female secondary schooling reduces a country's rate of growth by 0.9 percentage points
Knight, Loayza and Villanueva (1993)	• Log of percentage of working age population in secondary school and log of GDP per worker • 98 non-oil countries, 1960-1985	• The estimated coefficient of human capital proxy is negative for the samples
Islam (1995)	• Average years of schooling and real GDP per capita • 1960- 1985	• Education variable is not significant in two out of three samples, and in all three samples the coefficient on the human capital variable appears (in the restricted version of the model) with the wrong sign
Barro and Sala-i-Martin (1995)	• Log of average years of schooling for total population aged 25 and log of per capita GDP • Cross-sectional, pooled and panel estimation for 79 non-oil countries,1960- 1985	• A positive link found for the cross-section. • Incorporating the time dimension of the human capital variable into the analysis tends to annihilate the effect that the cross-sectional variation in human capital had on the regression results.
Pritchett (1996)	• The growth of years of schooling and per annum growth of GDP per worker • Analyses growth effects for 91 countries, -1960- 1985	• Estimates of the impact of growth in educational capital on growth of per worker GDP are consistently small and negative
Gemmell (1996)	• Average annual per capita GDP and log of the initial stock of primary, secondary and tertiary human capital • Human capital measures based on attainment at the primary, secondary and tertiary levels • Growth rate of primary, secondary and tertiary human capital stock OLS estimation and 3SLS with an investment equation • 1960- 1985, 98 countries	• Support for a role for both initial stocks and subsequent growth of human capital in fostering faster income growth • A 1 percent increase in tertiary human capital stock was associated with a 1.1 percentage point increase in per capita GDP growth rate • An indirect relationship between human capital, investment and growth exists such that education has a positive effect on investment which feeds through to growth

Table 1. (continued) Summary table on related macro-economic empirical studies

Study	Variable used and methodology	Estimated coefficient and interpretation
Growth regressions		
Barro (1998)	• Birth and educational attainment data from Barro and Lee (1993) • Panel data (random effects) estimation, 116 countries from 1965 to 1985	•Similar to Barro (1993)
Bassanini and Scarpetta (2001)	• Pooled mean group (PMG) estimator	• An elasticity of 0.6 for output per capita in response to additional years of schooling.
Temple (2001)	• Investments in education and GDP per capita in developing countries.	• Large investments in education have also yielded very small pay-off
Andreosso-O'Callaghan (2002)	• SER and GDP growth rate • Panel data, 10 Asian economies over the 1980-1997 period	• Positive and significant link
Baldacci, Clements, Gupta and Cui (2004)	• Education spending and GDP growth rate • Panel data from 120 developing countries from 1975 to 2000	• An increase in education spending of 1 percentage point of GDP is associated with 3 more years of schooling on average and a total increase in growth of 1.4 percentage points in 15 years

A summary would concur with Temple (2001), who notes that "the empirical evidence that education matters for growth is surprisingly mixed." It is also a fact that the majority of studies are concentrated on cross-section and panel data analysis for cases of developed countries, with scarce amount of work based on developing countries and to our knowledge none exclusively for an African panel set. Moreover, the issue of endogeneity and dynamics in the education-growth link has been ignored until lately.

III. Education in Africa

Africa's level of "human development" is the lowest of any region in the world. Its poor economic performance is a known fact and has been reflected in its growth rate. The continent has performed relatively poorly in each of the three dimensions of the human development index (HDI) and the 2002 United Nation Development Programme

Human Development Report shows that Africa has the lowest level of human development of any region. Moreover, Africa though registering an increase in its adult literacy and combined school enrolment since the last two decades, still remains among the lowest in terms of school attainment. Table 2 shows comparative primary and secondary enrolment ratio of various regions of the world. Although Africa's performance remains poor as compared to others, both educational ratios have been seen to constantly increase over the years and the continent has shown considerable promise. Interestingly, the annual rates of change in the absolute number of pupils and school age population since 1980 is highest for Africa. In fact, the average rate has been 5.6% for Africa as compared to 2.9% for the world during the period 1980-2002. This has also been translated in a constant rise in the number of years of schooling (see Table 3). Indeed all African countries have made substantial gains in adult literacy since 1970.

Table 2. Primary and secondary enrolment ratio

Region	Secondary enrolment ratio (SER)			Primary enrolment (PE)		
	1990	1995	2002	1990	1995	2002
Africa	30	32	37	76	79	92
East Asia	45	58	70	118	115	111
South America	57	78	97	120	123	122
West Asia	42	45	53	90	92	101
Europe	96	97	105	100	101	103
North America	76	78	84	102	104	104
World	52	58	65	100	100	104

Source: UNESCO Institute for Statistics.

Table 3. Years of schooling by region

Regions	1990	1998	2001	2004
Sub Saharan Africa	6.1	6.8	7.1	7.5
Central Asia	11.6	11.1	11.4	
East Asia	10.2	10.5	10.9	11.3
South/West Asia	8.4	7.6	8.6	9.8
Latin America	10.4	12.9	13	13.3
N America/W Europe	14.8	16.1	16.3	17
Central Eastern Europe	11.4	11.8	12.7	13.2
World	9.3	10	10.3	10.5

Source: Statistical Annex, Table 17, UNESCO Institute for Statistics Database.

In 2000, the average literacy rate in Sub-Saharan Africa was 52 per cent for women and 68.9 per cent for men, with gender disparities prevailing in 75 per cent of the countries in the region. At present, the gross secondary school enrolment rate exceeds 20 per cent in half of sub-Saharan African countries, yet remains below 8 per cent in ten of these countries. Enrolment rates in higher education in Sub-Saharan Africa are by far the lowest in the world. Although the gross enrollment ratio has increased in the past 40 years –it was just 1 per cent in 1965– it still stands at only around 5 per cent in 2002.

Literacy rates also vary enormously across the continent, from less than 20% in Niger and Burkina Faso to over 80% in Mauritius, the Seychelles, South Africa and Zimbabwe. School enrolment statistics exhibit almost as much variation. Some countries have achieved almost universal primary education. Southern African countries (with the exceptions of Angola, Botswana and Mozambique) have noticeably higher enrolment rates whilst many countries bordering the Sahara desert tend to have lower than expected enrolment rates. Gender inequalities also vary considerably across African countries.

IV. Methodology and analysis

A. The economic model

We use two models to test the economic importance of education for the African region. In the first instance, we regress a proxy of economic development on measures of human capital while controlling for the other variables of an aggregate production function. This follows Griliches (1997, p. 333) who wrote that "the main, and possibly only, approach to testing the productivity of schooling directly is to include it as a separate variable in an estimated production function". The key attraction of growth regressions is that they provide a way of testing directly for productivity effects of education. A Cobb-Douglas production function is thus specified whereby education enters as an additional and separate input (equation 1). This is consistent with works from Benhabib and Spiegel (1994), Gemmell (1996), Klenow and Rodríguez-Clare (1997) and more recently from Pina and St. Aubyn (2005):

$$Y = A_t (K_t)^{\beta 1} (L_t)^{\beta 2} (H_t)^{\beta 3}, \quad (1)$$

where Y, the country's output level, is measured by real gross domestic product per capita at constant prices and was generated from the *International Financial Statistics'*

(IFS) various yearbooks, *K* is the country's investment ratio, *L* is the amount of people in employment (a measure of Labour) and *H* is the secondary enrolment ratio and proxies for the quality of human capital.[2] We use secondary enrolment ratio as this is the only consistent proxy available over the period of study and for the whole sample.[3] The use of interpolations was kept to a strict minimum. The study also uses another proxy for education, namely, number of schooling years, for robustness. However, the time span of the studies is restricted to the period 1990-2000 due to unavailibility of such data for all the countries. The results obtained with this proxy are very similar.

Data for the independent variables, namely, *K* (investment ratio) and *L* (employment), have been obtained from the IFS, and the secondary enrolment ratio from the World Development Report (various issues) and from each country's respective Central Statistical Offices.

We also try an alternative approach that follows the bulk of the literature (Barro 1991, 1998; Mankiw, Romer and Weil 1992; Islam 1995; Krueger and Lindahl 2001 and Baldacci et al. 2004 among others) which adopts a cross-country growth regression approach, specifying per capita GDP as a function of a set of explanatory variables, including education measures. The following economic model is thus specified:

$$Y_{it} = \beta_0 + \beta_1 K_{it} + \beta_2 XMGDP_{it} + \beta_3 H_{it} + \beta_4 POL_{it} + \beta_5 FD + \varepsilon_{it}, \quad (2)$$

where *K* and *H* are defined as above, *XMGDP* is total of export and imports divided by the GDP of the country and is a measure of openness, *FD* is a proxy of financial development and is measured as the ratio of liquid liabilities to the country's Gross Domestic Product (GDP). It a typical measure of "financial depth" and has been widely used (King and Levine, 1993). We also include a measure of political instability (*POL*), namely, the political risk rating as provided by the International Country Risk Guide in its 2003 *Brief guide to the ratings system*; the rating awards the highest value to the lowest risk and the lowest value to the highest risk and provides a mean of assessing the political and institutional framework of the countries (see the 1999 ICRG *Brief guide to the ratings system*). The time span of the study

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[2] We use the investment share to GDP, as a proxy for capital due to the unavailability of capital stocks for the majority of countries in our sample. Gemmell (1996), Islam (1995), Knowles and Owen (1995), and Krueger and Lindahl (2001) also use investment ratios in their studies.

[3] Levine and Renelt (1992) and Englander and Gurney (1994) among others use such an education proxy.

was brought down to the period 1985-2000 due to unavailability of data. In fact by concentrating on Africa, a number of variables relevant in a global context were excluded mainly due to data unavailability and these include rule of law, black market premium, and the standard deviation of black market premium among others.

Table 4. Descriptive analysis

	Y	*K*	*H*	*XMGDP*	*FD*	*POL*
Mean	2473.7	9.257	25.707	0.6622	0.3018	23
Median	1270.9	7.667	21	0.5640	0.2438	35
Std. Deviation	2495.2	6.185	17.975	0.3638	0.2086	3.452
Kurtosis	2.556	8.048	1.326	3.5787	4.4795	3.456
Skewness	1.790	2.212	1.168	1.4609	1.7631	1.345
Minimum	443.1	1.105	2.8	0.0139	0.0001	10
Maximum	13931.7	47.685	95.3	2.7673	1.629	87
No of Observations	840	840	840	720	720	720

Note: the investment share to GDP is used as a proxy for physical capital due to the unavailability of capital stocks for the majority of countries in the sample.

B. The econometric model and preliminary tests

From equations (1) and (2) above, taking logs on both sides of each equation and denoting the lowercase variables as the natural log of the respective uppercase variable, results in the respective econometric specifications:

$$y_{it} = \beta_0 + \beta_1 k_{it} + \beta_2 l_{it} + \beta_3 h_{it} + \varepsilon_{it}, \tag{3}$$

$$y_{it} = \beta_0 + \beta_1 k_{it} + \beta_2 xmgdp_{it} + \beta_3 h_{it} + \beta_4 pol + \beta_5 fd + \varepsilon_{it} \tag{4}$$

From equation (3) and (4), β_0 is the constant term and β_j (j =1 to 5) represent the elasticity of output relative to various inputs, i denotes the respective countries in the sample and t the time period.

C. Cross-section, pooled OLS and panel analysis

Cross-section, pooled OLS, random effects and first step generalised method of moments (GMM) techniques are used to identify and compare the role of education in economic development within both econometric specifications. We start by the

cross section (averaged over the sample period 1980-2000 and 1984-2000 respectively) and pooled OLS estimates (containing countries and year dummies) of the econometric model.

The limitations of using a single-equation OLS cross sectional regression model and pooled OLS are known.[4] To overcome these short comings, panel data techniques are advised. The paper still reports, for comparative purposes and to get a broad overview, the above estimates. We correct the standard errors of the OLS regression by the White procedure. The procedure adjusts for the presence of heteroskedasticity in the data.

The cross section regression and pooled OLS results are reported in Table 5. The cross section analysis (refer to columns 2 and 3 of Table 5) shows a positive coefficient of h, although insignificant for model 1. From the latter, the level of investment, as expected, is reported to have played a major role in explaining economic growth. Employment level, a proxy of labour, is also seen to be positive and significant. Model 2 also reports the sizeable role of investment and also suggests that openness, financial development and political instability are important ingredients in the economic growth equation. Pooled OLS analysis (refer to columns 4 and 5) confirms the positive and significant economic contribution of education for African economies. The other explanatory variables are well behaved and have generally the expected sign and significance.

A central issue before making the appropriate specification, often ignored by past researchers, is to test if the variables are stationary or not. We thus carry out panel unit root tests on our variables. Following the approach of Im, Pesaran, and Shin (IPS) (1995), who developed a panel unit root test for the joint null hypothesis that every time series in the panel is non stationary, a unit root is rejected in favor of stationarity at the 5 percent significance level (the results were also confirmed by the Fisher-ADF and Fisher-PP panel unit root tests).

Use of panel data allows not only to investigate dynamic relations, but also to control for unobserved cross-country heterogeneity. With panel data, the issue is to determine which of the fixed or random panel technique is more appropriate to estimate our model. The Hausman test, which tests that the null hypothesis that the coefficients estimated by the efficient random effects estimator are the same as the ones estimated by the consistent fixed effects estimator, is employed. The test

[4] The most serious limitations being that simple cross section may produce biased and inconsistent estimates since they may not take into consideration the endogeneity of some of the regressors. It ignores dynamics and throws away information (Arrelano and Bond 1991) and may suffer from omitted variable bias.

favours the random effects model in both specifications (refer to p-value values, reported in Table 5, last two columns).[5] Moreover, the null hypothesis of homoscedasticity is also rejected at 1%, so the White correction is adopted to obtain heteroscedasticity consistent estimation and the robust estimates are shown in the 6th and 7th columns of Table 5.[6]

Table 5. Log of GDP per capita (*y*), 1980-2000: cross-country and pooled OLS estimates

Variable	Cross-section estimates		Pooled OLS		Random effects estimates	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Constant	5.57	2.33	6.07	2.45	6.7	1.22
	(7.23)***	(3.23)**	(37.18)***	(21.23)***	(49.6)***	(32.32)***
k	0.77	0.45	0.71	0.41	0.64	0.52
	(5.95)***	(3.45)***	(27.02)***	(24.23)***	(38.16)***	(22.34)***
h	0.26	0.16	0.19	0.13	0.21	0.15
	(1.37)	(1.89)*	(5.84)***	(3.22)***	(9.21)***	(5.34)***
l	0.11		0.13		0.19	
	(1.81)*		(9.49)***		(15.83)***	
xmgdp		0.17		0.23		0.32
		(1.85)*		(1.88)*		(1.99)*
pol		-0.11		-0.15		-0.27
		(1.67)		(2.12)**		(2.55)**
fd		0.07		0.11		0.09
		(1.95)*		(1.79)*		(1.89)*
R^2	0.66	0.56	0.59	0.61	0.31	0.37
No. observations	40	40	840	756	840	756
Hausman test					Prob>Chi2= 0.8937	Prob>Chi2= 0.8246

Notes: *significant at 10%, ** significant at 5%, ***significant at 1%. The small letters denote variables in natural logarithms. The quantities in brackets are the heteroskedasticity robust t-values. Year and country dummies are not reported in the table for the case of pooled OLS.

[5] A Breusch–Pagan Lagrange Multiplier (LM) test is also used to test if the variance of the intercept components of the composite error term is zero and confirmed the use of random effects estimates.

[6] The Bhargava, Franzini and Narendranathan (1982) BFN test also confirmed no serial correlation.

Referring to the heteroskedastic consistent coefficients from model 1, education has been an instrumental factor in promoting economic performance in Africa.[7] This confirms the results of the cross-section and pooled OLS obtained earlier. An output elasticity of 0.21 indicates that a 10% increase in the secondary enrolment ratio (proxy for education) for countries in the sample is accompanied by a 2.1% increase in output level. Estimates from model 2 corroborate the fact that education has a positive role in economic performance, though a lower coefficient of 0.15 is found. The results confirm the positive link found in the literature for developing countries, particularly from Psacharopoulos (1994) for the case of African countries, Andreosso-O'Callaghan (2002) for Asian counties and Baldacci, Clements, Gupta and Cui (2004) for a sample of developing countries. It should be noted that the estimates are lower compared to the results from similar studies from Mankiw, Romer, and Weil (1992), Levine and Renelt (1992), and Bassanini and Scarpetta (2001) based mainly on developed country cases. This might be explained by the fact that education in Africa has not attained a critical threshold and also because Africa's adoption of technology has been lagging, thus mitigating the full returns from education. The rest of the determinants of growth are seen to generally have the expected sign and significance with investment and to a lesser degree level of openness playing the most important role in explaining growth in Africa.

D. Dynamic panel data regression

Reverse causality is an issue when studying the relation between output and education, because of the fact that causality runs from output (or anticipated output) to education, and not simply vice versa. To a large extent, long-run changes in average educational attainment are driven by government policy. It seems plausible that as output and tax revenues increase, governments might allocate more resources to education, thus increasing its standards, attainment and quality.[8] Moreover better education may have a signaling effect and attract more domestic and foreign direct investment to the country, thus increasing output. The issue of causality and dynamics are thus important

[7] The results are also confirmed when using the number of schooling years instead of the secondary enrolment ratio as a proxy for level of education. However the estimates were based on 18 African countries and over the time period 1990-2000.

[8] The two-way interaction between growth and education is discussed in more detail by Bils and Klenow (2000). Bils and Klenow argue that the direction of causality may be uncertain even when attention is restricted to the growth effect of the initial level of education.

to the analysis of our hypothetised link. If the possibility of endogeneity is present there might be the loss of dynamic information even in a panel data framework.[9]

The generalized method of moments (GMM) estimators, developed for dynamic models of panel data and introduced by Arellano and Bond (1991), have thus been used to account for the above fact. The incorporation of dynamics into our model requires that the equation above be rewritten as an AR (1) model, that is:

$$y_{it} - y_{it-1} = \alpha_t + \lambda y_{it-1} + \beta x_{it} + \mu_i + \varepsilon_{it}, \tag{5}$$

where y_{it} is the logarithm of real per capita GDP, $y_{it} - y_{it-1}$ is the rate of per capita income growth, x_{it} is a vector of explanatory variables, with $x = [y,k,h,l]$ for model *1* and $x = [y,k,xmgdp,h,pol,fd]$ for model 2, μ_{it} is an unobserved country specific effect, ε_{it} is the error term and the subscripts *i* and *t* represent country and time period respectively, while α_t are the period specific intercept terms to capture changes common to all countries.

Equivalently, equation (5) can be written as

$$y_{it} = \alpha_t + (\lambda + 1)y_{it-1} + \beta x_{it} + \mu_i + \varepsilon_{it} \tag{6}$$

To eliminate country-specific effects, we take the first differences of (6):

$$y_{it} - y_{it-1} = (\alpha_t - \alpha_{t-1}) + (\lambda + 1)(y_{it-1} - y_{it-2}) + \beta(x_{it} - x_{it-1}) + \varepsilon_{it} - \varepsilon_{it-1} \tag{7}$$

or

$$\Delta y_{it} = (\alpha_t - \alpha_{t-1}) + (\lambda + 1)\Delta y_{it-1} + \beta \Delta x_{it} + \Delta \varepsilon_{it}. \tag{8}$$

Since y_{it-1} might be endogeneous to the error terms through ε_{it-1}, a problem of endogeneity exists and it will therefore be inappropriate to estimate the above by OLS. To overcome this problem of endogeneity, an instrumental variable needs to be used for Δy_{it-1}. Two approaches, namely instrumental variable (IV) and two GMM estimators, first and second step respectively, can be used in this regard. We use the latter technique, as the IV approach leads to consistent but not necessarily efficient estimates of the parameters (see Baltagi 1995). Moreover, the first step GMM estimator will be used since it has been shown to result in more reliable inferences. The asymptotic standards errors from the two step GMM estimator have been found to have a downward

[9] Durbin-Watson tests confirm the endogeneity of our education indicator.

bias (Blundell and Bond, 1998). The results from estimating equation (8) using the Arellano-Bond (1991) first step GMM estimator are contained in Table 6.

Table 6. GDP growth (*dy*), 1980-2000: dynamic panel data estimation

Variable	GMM estimates (first step estimator)	
	Model 1	Model 2
Constant	0.006	0.124
	-0.72	-0.95
dy_{t-1}	0.707	0.544
	(9.30)***	(6.34)***
dk	0.04	0.09
	(1.75)*	(1.95)*
dh	0.01	0.08
	(1.88)*	(1.94)*
dl	0.19	
	(1.68)*	
dxmgdp		0.12
		(2.13)*
dpol		-0.04
		-0.34
dfd		0.023
		(1.92)*
Diagnosis tests:		
Sargan test of overidentifying restrictions	prob>chi2=0.06	prob>chi2=0.06
Arellano-Bond test of 1st order autocorrelation	prob>chi2= 0.09	prob>chi2= 0.09
Arellano-Bond test of 2nd order autocorrelation	prob>chi2=0.437	prob>chi2=0.437

Notes: *significant at 10%, ** significant at 5%, ***significant at 1%. The small letters denotes variables in natural logarithms, d denotes variables in first difference and the heteroskedastic-robust z-values are in parentheses.

The positive and significant education indicator reported from the dynamic panel analysis supports the result of the static model using random effects estimates. The smaller reported short run coefficient suggests that education may take in fact some time to achieve its full potential. This is also the case for the investment variable, openness and financial development as well in case of model 2. The positive lagged value of the dependent variables suggests the presence of important dynamic effects in the education-growth link. This is in line with recent works from Pina and St. Aubyn (2005) who, however, used time series analysis for the case of Portugal.

V. Summary of results

Studies on the relationship between education and economic performance for the case of developing countries, particularly for Africa, have been very scant. Africa experienced a massive growth of enrolment at all levels of education during the second half of the 20th century, especially since the 1970s up till 1995, when gross enrolment rates doubled at the primary level and increased eightfold at the secondary level. The paper investigates if this phenomenal growth in education in Africa has translated into higher growth prospects for a sample of African economies. It uses two models, a Cobb-Douglas production function and a growth equation, for the periods 1980-2000 and 1985-2000 respectively, in both a static and a dynamic panel framework. Preliminary results from cross sectional and pooled OLS analysis show that education has a positive impact on growth for both economic specifications. Random effects panel data estimates suggest that education, as proxied by secondary enrolment ratio, has been instrumental to the economic growth of those African states in the sample. The results confirm the positive link found in the literature for developing countries and it is observed that the estimates are lower as compared to the results from similar studies. The study further investigates the link in a dynamic framework using GMM methodology and the results back those found in the previous analysis. Moreover, it provides evidence of endogeneity and dynamics in the link. The results thus supplement the existing literature by providing additional evidences from a panel of African countries.

As far as policy implications are concerned, this study suggests African policy makers should understand that education is an important ingredient for higher growth prospects and that it has important indirect economic effects as well. These governments should tap development loans given by international financial institutions. Investment in education can also take the form of public-private partnerships. The need for educational reform in the region has grown urgent and it will be necessary to focus on the quality of education.

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