Was education a driver of economic development in Africa?
Inequality and income in the twentieth century

Bas van Leeuwen*, Jieli Van Leeuwen-Li*, and Peter Foldvari*

Very preliminary version

SUMMARY

In this paper, we tried to address the issue how education affects economic welfare. We find that in the long-run neither education nor physical capital affects per capita income growth. This seems to suggest that it were inspiration (i.e. TFP) rather than perspiration (i.e. education and physical capital) factors that drove economic development. However, TFP growth can be subdivided in the growth of general productivity (i.e. a productivity frontier that indicates the maximum possible productivity per capita), and technical efficiency (i.e. how efficient education and physical capital are [how far they are from the technical frontier]). We find that education does have a positive effect on technical efficiency (whereas physical capital has a negative effect) implying that education is necessary to adopt skill biased technology in the productive process. This leads to a small, but significant, effect of education on TFP growth.

Yet, it remains clear that it is largely productivity growth, rather than anything else, that drives African economic growth. Combined with a decrease in technical efficiency (i.e. more countries stay further from the productivity frontier) this implies a strong increase in inequality in Africa.

We argue that there are basically three ways in which education may affect inequality. First, an increase in the level of education increases average income, which, *ceterus paribus*, reduces inequality. This has clearly been rejected since we hardly found any effect of education on per capita income. Second, a rise in education may reduce educational inequality. Since the private returns to education are positive, this suggests a reduction in income inequality. Thirdly, an increase in education may increase the supply of education and, as a consequence, lower the price of skilled labour, i.e. lowering income inequality. Testing the latter two effects, we found there was indeed a strong, non-linear, relationship between educational and income inequality. This implied that, reducing educational inequality in 2010 to zero, would have caused a decline in income inequality by no less than 81%.

KEYWORDS

Africa, human capital, economic growth, growth accounting, inequality, 20th century

**Utrecht University.*

Corresponding author: Bas van Leeuwen (bas.vanleeuwen1@googlemail.com)

1. Introduction

Education is often seen as a main driver of economic welfare. That is, it increases a person's welfare by increasing its productivity (e.g. Nelson and Phelps 1966; Lucas 1988; Romer 1990) or it improves a countries institutional structure by enhancing democracy (e.g. Perotti 1996, Alesina and Perotti 1996). Yet, remarkably little attention has been devoted to the role of education in the, much discussed "African growth tragedy". So far, also because of lack of data, much of the discussion has focussed on what may be called the "ultimate sources of growth". Some have stressed the geographical factors such as the geography and disease environment (e.g. Sachs and Warner 1995; Gallup et al. 1998) while others have focussed on institutions such as colonial policy (e.g. North, Summerhil and Weingast 2000) and their effect on the endowment structure (e.g. Easterly and Levine 1997; Acemoglu et al 2002, and Rodrik 2002).

This kind of literature may be seen as bad news for Africa since the underlying factors driving economic growth are not (or only slowly) changing over time. It also does not explain reversals of growth patterns after independence as pointed out by Prados de la Escosura and Smits (2007, p. 3). Indeed, whereas in the 1960s it was argued that African growth potential outstripped that of Asia (Kamarck 1967), currently we are speaking about a "growth tragedy".

In order to explain the changing fortunes of Africa over time we need to have a more dynamic view on the factors driving its growth. This can be done by recognizing that institutions and geography may also work via the factors of production (i.e. Eicher et al. 2006). Indeed, it has been widely recognized that Africa lacked in both education and physical capital (e.g. Cohen and Soto 2002; Frankema 2011). Given the importance that many current growth theories attach to education, it is important to give this factor its rightful place in quantitative studies on African welfare performance. Indeed, according to Prados de la Escosura (2011), education was driving what little development there was in the Human Development Index (HDI) in Africa since the 1930s (Prados de la Escosura 2011). However, this is much an artificial index with assumed weights while education may also have indirect effects via per capita income.

Therefore, in this paper we try to give education its place back by looking at how it affects the indicators of welfare, i.e. GDP per capita and inequality. In the next section we will provide a brief discussion on the data and the main trends in development in Africa in the twentieth century. Section 3 then discusses the effect of education on per capita income. We find that education has a small direct and indirect effect on growth. However, this is not true for within country inequality which we find to be strongly driven by educational inequality in Section 4. We end with a brief conclusion.

2. African economic development

The first question we need to ask ourselves when interested in how education affected economic and social development is: how did Africa actually developed in the twentieth century? This question is not straightforward since the data, if available at all, mostly start around 1950. Therefore, in this Section we discus African economic development with the emphasis on the five regions as used by the United Nations (i.e. North, West, Central, East and Southern Africa).[1]

[1] *North Africa:* Algeria, Egypt, Libya, Morocco, Sudan, Tunisia; *West Africa:* Benin, Burkina Faso, Ivory Coast, Gambia, Ghana, Guinea, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo; *East Africa:* Burundi, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Seychelles, Somalia, Tanzania, Uganda, Zambia, Zimbabwe; *Central Africa:* Angola, Cameroon, Central African Republic, Chad, Congo (Brazzaville), Congo (Kinshasa), Gabon; *Southern Africa:* Botswana, Namibia, South Africa, Swaziland.

The most commonly used variable to indicate welfare is per capita GDP. Most information after 1950 is taken from Maddison (2007). For the recent years, however, we used the updates from the Conference Board Total Economy Database (2012). Unfortunately, except for some benchmark estimates from Maddison (2007) almost no information on per capita income is available before 1950. Therefore, we aimed at making some conjectures on regional per capita income developments in Africa in the first half of the twentieth century. There are three ways to address this issue. First, in the literature some additional evidence on per capita income for certain countries in Arica before 1950 are available. Second, we can use real wage data to proxy per capita incomes from the work of Frankema ad Waijenburg (2011). Even though per capita GDP is obviously not identical to real wages, their trends may not differ to much if the share of profits, farmer incomes do not change much over time and if days worked also do not change much. However, there is little evidence for this to be the case. Thirdly, Prados de la Escosura (2011), used trade data to project GDP per capita back to 1870. He used a regression of GDP per capita on income terms of trade per head, a time trend, and several dummy variables capturing colonizer, regional, and whether or not a country was located at a coast. Hence, if we assume that the growth of the indigenous economy was a linear function as captured by a time trend* terms of trade, this method should capture reliable results. Indeed, over time the effect of terms of trade on GDP per capita gets larger, suggesting a bigger dependency on the trade sectors. Unfortunately, there is no reason to assume it is linear nor that in some regions the trading sectors will have grown faster than in others and hence, GDP per capita to be underestimated when going back in time. Hence, it is important to compare all three methods.

For North Africa, we may obtain data from GDP estimates from Amin (1966, pp. 104-105) who covered benchmark years between 1880 and 1955 for Algeria, for 1910-1955 for Tunisia, and 1920-1955 for Morocco. All these data were connected to 1950 benchmark in 1990 GK dollars. For Egypt, our data were drawn from Yousef (2002). We assumed the population weighted average of per capita GDP of these countries to reflect the trend in North Africa for the period before 1950 (see Table 1). It is important to stress, however, that the Yousef data show higher growth rates than those of Hansen and Marzouk (1965) and Hansen (1979, 1991), especially before 1900. Hence, our estimates for 1890 are slightly lower than would have been the case when using the Hansen data. One way to cross check this result is to compare with estimates from Prados de la Escosura (2011) who finds GDP per capita in North Africa in 1890 to be 802 GK dollars versus 559 in our estimates. The main reason for this difference is Egypt. Unfortunately, it is difficult to substantiate which series to believe. However, looking at the real wage series for Egypt (Williamson 2000), the series from Yousef (2002), on which our series is based, moves quite well in line while the Hansen (1979, 1991) series seems to be slightly higher when going back in time. The Prados de la Escosura (2011) series seems considerably higher.

For West and East Africa, much less direct data on GDP is available. For West Africa the best data is probably for Ghana from Szereszewski (1965, pp. 74, 92-3, 126-149). He presents GDP data for 1891-1911and 1966. However, his estimates only let the "modern sector" change, while assuming the indigenous sector to remain the same over time. Since the indigenous sector is by far the largest, this means that economic development is limited. However, this seems highly unlikely since real wage series from Frankema and Van Waijenburg (2011) seem to indicate that the indigenous economy grew considerably in per capita terms between 1890 and 1950. Indeed, using real wage data, we find that GDP in 1890 for Ghana was around 760 GK dollars compared to ca. 610 for Szereszewwski (1965). This suggests that taking a trade based approach may underestimate the GDP for West Africa more in general. For East Africa, data are even scarcer. Deane (1946) calculated the national income of Northern Rhodesia (i.e. Zambia) at 7.63 mln GDP in 1938. Converting this to 1990

GK dollars, we arrive at 418 GK dollars. Fortunately, we do also have real wages (Frankema), which show that on average GDP per capita in 1910 was around 484 GK dollars. For Southern region of Africa (i.e. South Africa, Swaziland, Lesotho, Namibia, and Botswana), data were obtained from Krogh and Willers (1962, Table 1). We converted them in constant prices and linked them to 1950 benchmark average of these 5 countries.

The results of GDP/cap in Africa are reported in Table 1 below. We can see that per capita GDP increases from 683 GK dollars in 1900 to 2023 GK dollars around 2010. This result is slightly higher than Smits (2006) who set per capita GDP of sub-Saharan Africa at 524 GK dollars in 1913. Corrected for North Africa from Table 1, this results in an over-all

Table 1. **Per capita GDP in Africa by sub-region, ca. 1890-2010**

	North Africa	West Africa	Central Africa	East Africa	Southern Africa	**Total Africa**
1890	559	752				
1900	714	863		508		**683**
1910	832	586		484		**641**
1920	960	867		771	871	**836**
1930	1,059	1,230		600	1,329	**976**
1940	1,075	718		728	1,909	**889**
1950	1,085	757	729	800	2,425	**968**
1960	1,279	871	909	953	2,919	**1,151**
1970	1,648	1,098	1,036	1,178	3,904	**1,459**
1980	2,285	1,217	888	1,155	4,257	**1,657**
1990	2,354	1,041	812	1,061	3,764	**1,549**
2000	2,712	1,024	577	1,031	3,886	**1,575**
2010	3,590	1,436	749	1,245	4,972	**2,023**

African GDP/cap for Smits of around 610 GK dollars. Likewise, Prados de La Escosura (2011, Table D-4) estimated per capita GDP for Africa around 1913 at 772 GK dollars (and 642 dollars around 1890). This suggests that all three methods seem to generate more or less similar results. That being said, it is obvious that especially Southern Africa grew faster over the twentieth century than the other regions. An exception might be Northern Africa since the 1970s, which obviously profited from their oil reserves. The other regions, however, stagnated (or even declined, i.e. Central Africa) in per capita income.

But what is driving this income divergence? The crucial variable in this paper, and the one most attention goes out to, is education. The problem is that very little information is available. The earliest estimates are from Benavot and Riddle (1988) who report primary enrolment ratios (i.e. total number of students divided by the relevant age class) between 1870-1940. The most interesting finding is the small difference in primary school enrolment rates between sub-Saharan Africa and Northern Africa. However, their data is very difficult to interpret since the countries with the highest enrolment ratios have data going back in time furthest, causing an increasing bias when going back in time. Therefore, Morrisson and Murtin (2009) calculated average years of education for every tenth year for a set of 23 African countries between 1870 and 2010. For the period after 1960 they based their data largely on Cohen and Soto (2007) while in the early 19^{th} century they assume that enrolment goes linearly back to zero at the start of the nineteenth century. Finally, the most comprehensive dataset is perhaps the one from Barro and Lee (2010) who provide data on average years of education for most countries for every fifth year since 1950.

Unfortunately, neither of these datasets contains annual data nor do they cover a broad sway of countries and/or time periods while the one dataset that does contain annual estimates (Nehru et al. 1995) only covers a limited time period and is based on a perpetual inventory method (PIM) which is generally to be considered less reliable than estimates based on census data. Therefore, in this paper, our starting point is to calculate a new set of annual estimates of average years of education for most African countries. This is done with the method as described in Van Leeuwen and Foldvari (2012). In short, census data were obtained for benchmark years, most often from Cohen and Soto (2007). The inbetween years were calculated with a Perpetual Inventory Method (PIM) from Barro and Lee (2001). However, whereas the Barro and Lee method is shown to cause an overestimate when calculating backwards and an underestimate when calculating forwards, we use a weighted average of

Table 2. **Population weighted average years of education in Africa, ca. 1890-2010**

	Nehru et al. (1995)	Baier, et. al. (2006)	Cohen and Soto (2007)	Morrisson and Murtin (2009)	Barro and Lee (2010)	This text
1890				0.2		
1900				0.2		
1910				0.2		**0.3
1920				0.3		0.3
1930				0.4		0.5
1940				0.5		0.6
1950		1.5		0.7	0.8	0.9
1960	0.9	2.1	1.2	1.1	1.0	1.2
1970	1.3	2.8	1.5	1.5	1.4	1.7
1980	1.9	3.3	2.0	2.2	2.1	2.3
1990	*2.5	4.2	2.9	3.2	3.0	3.4
2000		4.8	3.7	4.0	3.6	4.3
2010			4.1	4.5	4.1	4.9

*1987, **1915

back-and forward extrapolation. For the period before the first census, we use a perpetual inventory method which corrects for age specific mortality. The enrolment data are obtained from UNESCO as made available by the Education Policy and Data Center (accessed 2011), Mitchell (1999), and for earlier periods from Frankema (2011) and House of Commons Parliamentary Papers (various issues). The population data were obtained from Maddison (2007), United States Census Bureau, International Programs (accessed 2011), and House of Commons Parliamentary Papers (various issues).

The results are reported in Table 1 together with some alternative datasets. Our estimates are almost the same as those of Cohen and Soto (2007) and Morrisson and Murtin (2009). This is not strange since all series for their post-1960 period are basically identical with some small differences. The main difference between our series and those of Morrisson and Murtin is that our dataset includes about twice the number of countries. The main difference, however, is that we did not find the enrolment ratio going linearly back to zero at the start of the 19th century as is assumed by Morrisson and Murtin (2009).

The question is how plausible our results are as compared to the competing series. They seemingly conform well to those of other datasets, but we can make an extra cross-check by, following Krueger and Lindahl (2001) calculating the reliability ratio. This ratio is essentially nothing else than regressing two alternative series of the real, but unobserved series of average years of education on one-another. Since the measurement error of the dependent variable is irrelevant, the resulting coefficient may be interpreted as the error to signal ratio of the dataset. The results are reported in Table 3. As one can see, our

Table 3. **Reliability ratio average years of education**

	Barro and Lee (2010) (1950-2010)	Baier et al. (2006) (1917-2000)	Cohen and Soto (2007) (1960-2010)	Morrisson and Murtin (2009) (1870-1950)	Morrison and Murtin (2009) (1950-2010)
estimated error-to-signal variance ratio, compared to own estimates	36.5%	297%	5.2%	13.3%	11.7%
the estimated error-to-signal variance ratio of own estimates compared to other estimates.	11.1%	13.1%	0%	11.9%	8.3%

Note: the method suggested by Krueger and Lindahl (2001) yields reliable results only if both compared series are unbiased estimators of the latent variable.

estimates outperform those of Barro and Lee (2010) and Baier et al. (2006) considerably. Yet, our estimates only slightly outperform the data from Cohen and Soto and Morrisson and Murtin in terms of the reliability ratio, which is unsurprising since they are based on similar underlying data. Hence, in terms of reliability it seems that the latter three datasets certainly outperform the rest.

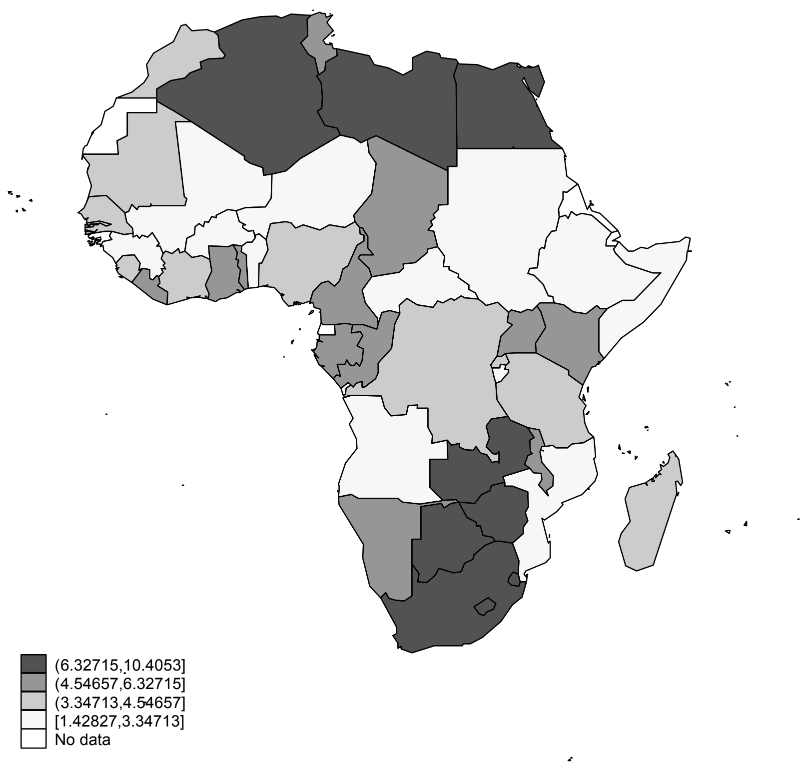
If we use these data to look at the long-run pattern of education in Africa by sub-region, we find that especially Southern Africa did well in terms of years of education. This

Table 4. **Average years of education in Africa by sub-region, ca. 1890-2010**

	North Africa	West Africa	Central Africa	East Africa	Southern Africa	**Total Africa**
1890		0.1				
1900		0.1				
1910*	0.2	0.1		0.2	1.8	**0.3**
1920	0.3	0.1		0.3	2.0	**0.3**
1930	0.4	0.2	0.2	0.5	2.4	**0.5**
1940	0.5	0.3	0.3	0.8	2.9	**0.6**
1950	0.7	0.4	0.5	1.0	3.5	**0.9**
1960	0.9	0.8	0.8	1.5	4.2	**1.2**
1970	1.4	1.2	1.2	1.9	4.7	**1.7**
1980	2.4	1.5	2.0	2.4	5.1	**2.3**
1990	3.9	2.5	3.1	3.3	5.7	**3.4**
2000	5.2	3.4	3.6	4.0	7.2	**4.3**
2010	6.1	3.9	4.0	4.5	8.5	**4.9**

*1915

Map 1. **Average years of education in Africa, 2010**



was true both in the early and late 20th century. However, the North caught up considerably since the 1970s. The remaining regions, though, performed at a more or less comparable level. This pattern is not entirely implausible. For example Crayen and Baten (2007), using age heaping methodology, found numeracy being higher, in Sub-Saharan Africa.

Hence, North Africa was a low performer until the 1970s both in terms of average years of education and in terms of numeracy. One explanation that springs to mind might be the Muslim presents in the North of Africa. However, Crayen and Baten (2007) warn against a religious explanation since neither the nearby Christian nor the Hindu populations had appreciably higher levels of numeracy compared to the North African Muslims. In addition, there were quite some differences even within North Africa in terms of numeracy and years of education. In North Africa, Algeria and Tunisia belong to those countries with highest levels of numeracy, and Egypt to the country with the lowest levels. This is similar to years of education, even though Sudan and Libya, two countries not included in the numeracy dataset, did even worse than Egypt.

These findings for education seem to indicate some relation with per capita income. After all, per capita income was also clearly higher in Southern Africa, economic growth also started in Northern Africa in the 1970s, and Egypt seemed to underperform compared to Algeria in terms of per capita GDP. However, in order to estimate the effect of education on per capita income, another crucial component needs to be included: physical capital. Omitting this from regressions inevitably leads to an omitted variable bias. As for physical capital we basically have 5 datasets: Baier, Dwyer and Tamura (2006), Miketa (2004), Easterly and Levine (2002), Nehru and Dhareshwar (1993), and the extended Penn World Tables (Marquetti and Foley 2011). Given the differences in the way these data are constructed, it is impossible to estimate the reliability ratio for the structural bias in the data. Hence, we make two datasets, one based on Miketa and Nehru (based largely on the WDI) and one based on

Table 5. **Correlation of physical capital series**

	Nehru and Dhareshwar (1993)	Miketa	Easterly and Levine (2002)	Baier, Dwyer and Tamura (2006)	Extended Penn World Tables
			Level-level		
Nehru and Dhareshwar	1.000				
Miketa	-0.124 (0.010)	1.000			
Easterly and Levine	-0.121 (0.012)	0.942 (0.000)	1.000		
Baier, Dwyer and Tamura	-0.088 (0.572)	0.926 (0.000)	0.975 (0.000)	1.000	
Extended Penn World Tables	-0.039 (0.417)	0.925 (0.000)	0.890 (0.000)	0.8145 (0.000)	1.000
			First differences		
Nehru and Dhareshwar	1.000				
Miketa	-0.089 (0.075)	1.000			
Easterly and Levine	-0.096 (0.054)	0.877 (0.000)	1.000		
Baier, Dwyer and Tamura	-0.111 (0.605)	0.842 (0.000)	0.863 (0.000)	1.000	
Extended Penn World Tables	-0.090 (0.072)	0.669 (0.000)	0.784 (0.000)	0.466 (0.000)	1.000

Note: Significance in parenthesis

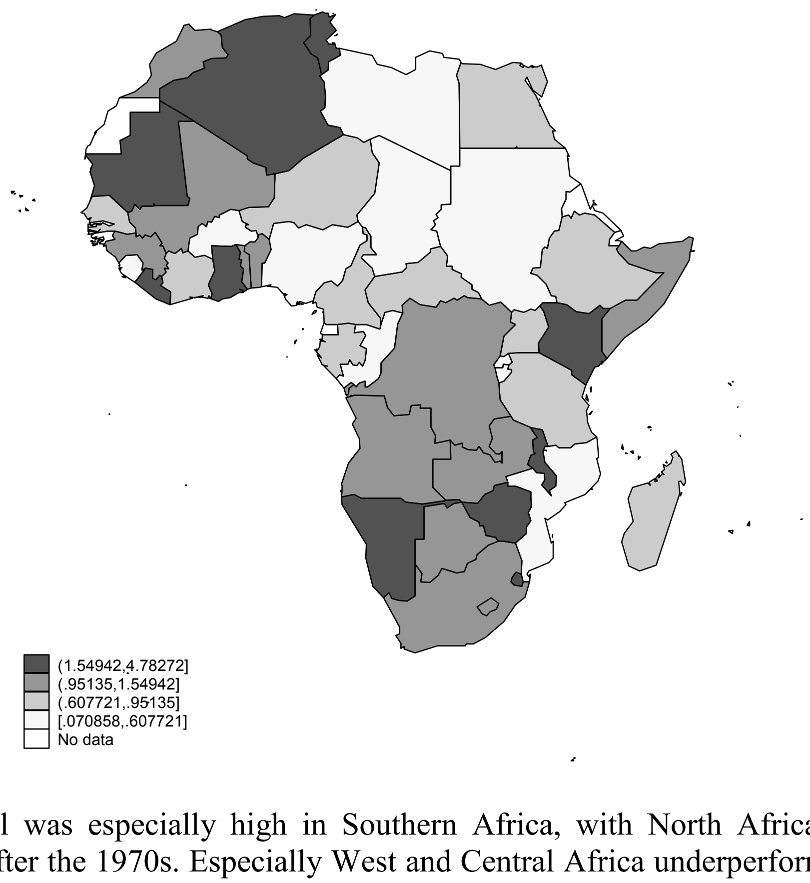
Easterly (based largely on the Penn World Tables). The results are reported in Table 5. Even though it is hard to make any statements, it seems clear that the Nehru series are the big outlier with actually negative correlation with the other series, both in level and first differences. The other series are largely comparable, even though it is clear that especially the Easterly and Levine (2002) and Baier, Dwyer and Tamura (2006) series have the strongest correlation (both levels and first differences). Therefore, and since it includes the most data, we prefer to start with the Extended Penn world Tables and add to that the Easterly and Levine (2002) and the Miketa (2004) data when appropriate.

The results are reported in Table 4, where we backcast physical capital with a regression including regional average years of education and per capita GDP. We find that

Table 6. **Per capita physical capital in Africa by sub-region, ca. 1910-2010**

	North Africa	West Africa	Central Africa	East Africa	Southern Africa	**Total Africa**
1910						
1920	753	617				
1930	1,032	904		647	803	**890**
1940	1,287	745	1,254	798	1,434	**1,015**
1950	1,538	796	1,077	932	2,404	**1,155**
1960	1,679	988	921	1,056	3,788	**1,403**
1970	2,094	1,116	939	1,256	5,376	**1,691**
1980	4,102	1,403	1,139	1,697	7,336	**2,560**
1990	4,527	1,015	1,058	1,603	6,059	**2,410**
2000	3,875	756	844	1,630	5,625	**2,062**
2010	4,881	944	819	1,764	7,250	**2,439**

Map 2. Physical capital/GDP ratio in Africa , 1960



physical capital was especially high in Southern Africa, with North Africa only growing spectacularly after the 1970s. Especially West and Central Africa underperformed. This again provides a comparable picture as produced for education, which seems to suggest there is a relation between per capita income and physical capital and education. However, it remains unclear how this relation runs. This is the topic of the following Section.

3. Should more education lead to higher mean income?

So far we noticed that higher education and physical capital go hand in hand with higher per capita income. In terms of the perspiration-inspiration debate (Krugman 1994) in which it is argued that most Southeast Asian growth is driven by factors of perspiration (i.e. the factors of production) rather than inspiration (i.e. Total factor Productivity [TFP]), this were to imply that something similar took place in Africa.

Yet, in order to truly analyze the role of education in economic development, it is important to first understand its mechanics. Indeed, the fundamental idea behind a positive role of education in economic development is twofold. First, it is based on the relationship between education and human capital, secondly, on the role of education in improving a societies' institutional structure ranging from more democracy through promoting a stronger civilian control on the government to higher life expectancy and life quality by promoting life-saving knowledge and techniques.

Regarding the first possible channel, the role of education as a main source of human capital, the picture is much less straightforward than the literature would suggest at first sight: there is no general agreement on how education is related to human capital, and as the latter is a latent variable, no simple approach exists to come to a conclusion to the problem. The most popular approach, however, either implicitly or explicitly uses education as a direct proxy of human capital. This is usually based on the Mincerian approach to investments in education and for this reason we will refer to this as the Mincerian approach (e.g. Hall and Jones 1999; Pritchett 2001). The fundamental idea here is that the per capita stock of human capital can be estimated from average years of education (S_t) and the rate of private returns to education (r_t) as follows:

$$\ln h_t = r_t S_t \quad (1)$$

where the rate of returns to education is often assumed to be a function of the average years of education.

We have already expressed critique of this approach in other papers (Van Leeuwen and Foldvari 2011, 2012), so instead of focussing on the same issues we rather identify the empirical consequences of the above approach and find out if empirics corroborate them. That is, if the above approach is correct more education should necessarily increase human capital and per capita income. If this is true, the answer to the question in the title of this section should be affirmative. Let us find out whether this is true.

A simple way to check both the short and long-run relationship between per capita income and education is to estimate an error correction representation of the production function of per capita GDP with physical capital and education as explanatory variables. The direction of causality is of no real importance for us, as we are looking for a long-run equilibrium relationship (cointegration). The unit-root tests (see Table A1) suggest that all variables are integrated of order one, so the theoretical possibility of cointegration does exists. The error correction specification is as follows:

$$\Delta \ln y_{it} = \beta_0 + \beta_1 \Delta \ln k_{it} + \beta_2 \Delta S_{it} + \beta_3 \ln y_{it-1} + \beta_4 \ln k_{it-1} + \beta_5 S_{it-1} + \eta_i + \lambda_t + u_{it} \quad (2)$$

where *lny*, *lnk* and *S* denotes the per capita GDP, per capita physical capital stock, and the average years of education. The immediate effects are reflected by the coefficients β_1 and β_2, while the long-run coefficients (cointegrating vector elements) and the adjustment coefficient can be estimated from the coefficients β_3-β_5. For comparison we also report the coefficients from a level on level specification (static panel) but the presence of a high degree of first order autocorrelation in the residuals is a clear sign of a spurious regression.[2]

[2] The ECM representation is basically a dynamic panel model, but as *T* is large, we do no need to be worried about the finite sample bias in fixed effect dynamic panel models.

Table 7. **Static and dynamic panel analysis of income on physical capital and education**

	$\ln y_{it}$	$\Delta \ln y_{it}$
constant	4.257 (9.47)	0.167 (4.89)
$\Delta \ln k_{it}$	-	0.196 (9.06)
ΔS_{it}	-	-0.045 (-1.95)
$\ln y_{it-1}$	-	-0.025 (-3.94)
$\ln k_{it-1}$	-	0.004 (1.17)
S_{it-1}	-	-0.005 (-2.15)
$\ln k_{it}$	0.354 (7.15)	-
S_{it}	0.092 (1.69)	-
R^2	0.921	0.164
N	2311	2265

Note: years and country dummies included but not reported.

While the level on level specification seems to suggest a positive relationship between education and per capita income, once we rewrite the specification into an error-correction model (ECM), this sign of the relationship turns to the opposite. More education seems to be paired with lower per capita income in the long-run. To be precise, the long-run effect is obtained as -0.005/0.025=-0.2, which is an economically significant effect: one additional years of education was paired with a 20% lower per capita income in the long-run. Another shocking result is that from the above specification we cannot find evidence in favour of a long-run relationship between physical capital and per capita GDP. There is a short-run positive effect, but the absence of a significant coefficient in the cointegrating vector suggests that investments do not result in some general improvement of the factors of production or productivity. Even though we are not the first to find similar results (e.g. Pritchett 2001), the counter intuitiveness of this finding urges us to turn to a panel VAR analysis as cross-check.

Even though PVAR is not a standard methodology yet, it has several advantages above estimating panel regressions for each of the variables independently. First, it is expected that there is a simultaneous relationship among our variables, at least between capital stock and per capita income, which would require instrumentation. Still it is very difficult to find correct, time-varying instruments for African countries. Second, estimating the impulse response functions (IRFs) allows us to estimate the short run and the long-run effects together in a more useful way. Finally, we do not need to specify a system of structural equations that would be based on several assumptions that are difficult to check.

We specify the following PVAR model is as follows:

$$\mathbf{Y_{it}} = \boldsymbol{\delta}_\mathbf{i} + \sum_{j=1}^{p} \boldsymbol{\Theta}_\mathbf{j} \mathbf{Y_{i,t-j}} + \boldsymbol{\eta}_\mathbf{t} + \mathbf{u_{it}} \quad (3)$$

where $\mathbf{Y_{it}} = (\ln y_{it}, \ln k_{it}, S_{it})'$, $\boldsymbol{\delta}_\mathbf{i}$ and $\boldsymbol{\eta}_\mathbf{t}$ are the country and the time specific effects, and $\mathbf{u_t}$ denotes vector of the residuals estimated from the PVAR. The country specific effects will be captured by country dummies, while the time specific effects are captured by a quadratic time trend.

The residuals are likely to be correlated due to simultaneous relationship among the endogenous variables. The primitive form of the above VAR system can be written as:

$$\mathbf{AY_{it}} = \boldsymbol{\alpha}_\mathbf{i} + \sum_{j=1}^{p} \boldsymbol{\beta}_\mathbf{j} \mathbf{Y_{i,t-j}} + \boldsymbol{\lambda}_\mathbf{t} + \boldsymbol{\varepsilon}_\mathbf{it} \quad (4)$$

where matrix A denotes a matrix of coefficients describing the simultaneous relationship among the endogenous variables, $\boldsymbol{\alpha}_\mathbf{i}$ and $\boldsymbol{\lambda}_\mathbf{t}$ are the country and the time specific effects, and $\boldsymbol{\varepsilon}_\mathbf{t}$ denotes vector of equation specific shocks.

The VAR coefficients will therefore be not equal to the coefficients from the primitive form, except if there is no simultaneity among the dependent variables (i.e. matrix A is a unit matrix):

$$\mathbf{Y_{it}} = \mathbf{A}^{-1}\boldsymbol{\alpha}_\mathbf{i} + \sum_{j=1}^{p} \mathbf{A}^{-1}\boldsymbol{\beta}_\mathbf{j} \mathbf{Y_{i,t-j}} + \mathbf{A}^{-1}\boldsymbol{\lambda}_\mathbf{t} + \mathbf{A}^{-1}\boldsymbol{\varepsilon}_\mathbf{it} \quad (5)$$

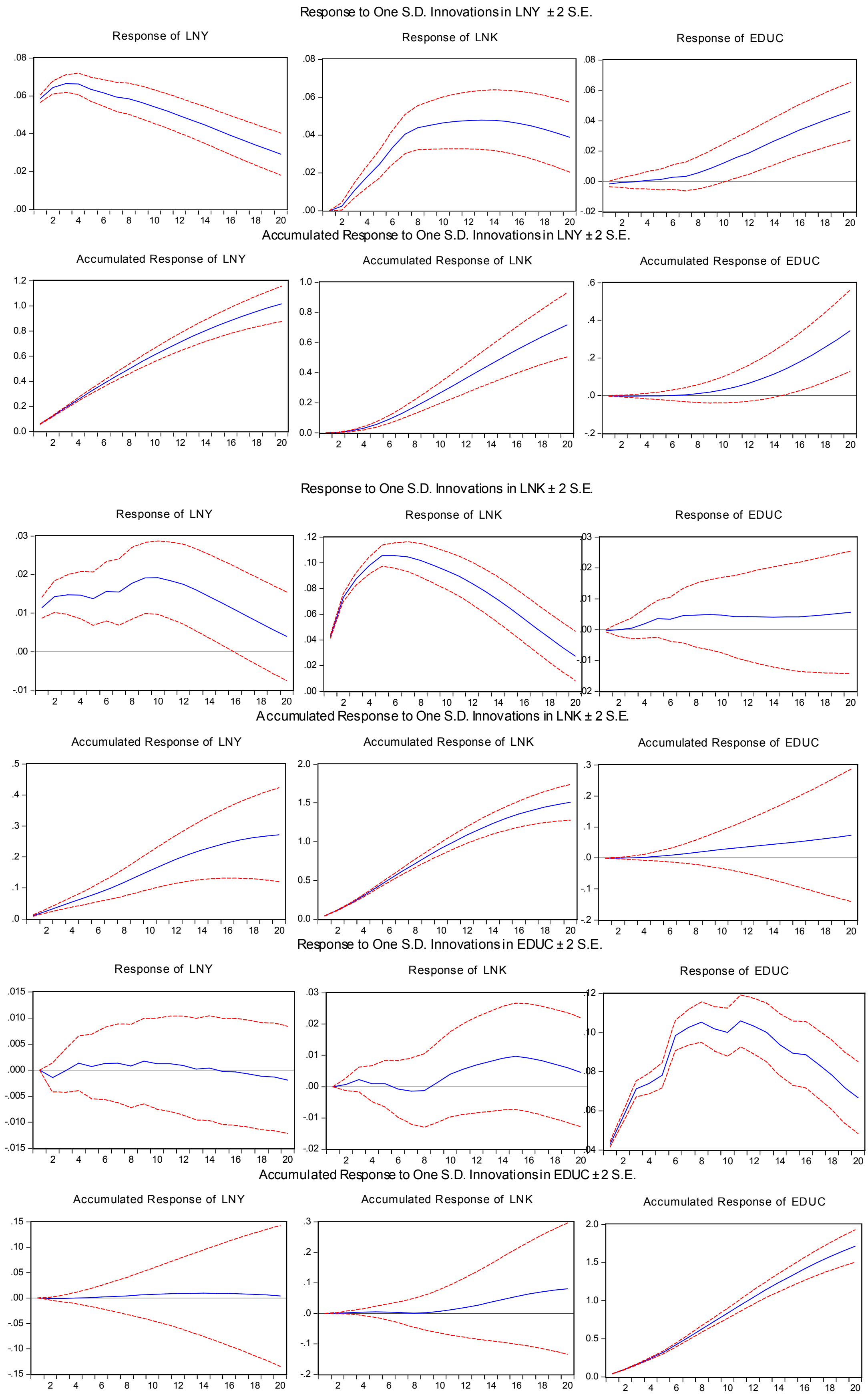
As a result, it is not possible to use the residuals as estimated from the VAR to obtain IRFs without identifying the matrix A (Structural VAR).

For the choice of the order of the VAR system we used the Akaike Information Criterion which preferred a VAR(9) specification when the quadratic trend was included and a VAR(11) when we included no trend. At these lag lengths the VAR system fulfilled the stability criterion, which is the fundamental requirement to obtain meaningful IRFs. Also the residual autocorrelation remained insignificant at 1%, but a total lack of serial correlation was not possible to achieve. We tested for cointegration with the Johansen test, but we found that the matrix Π in the following VEC representation:

$$\mathbf{\Delta Y_{it}} = \boldsymbol{\delta}_\mathbf{i} + \sum_{j=1}^{p-1} \boldsymbol{\Gamma}_\mathbf{j} \mathbf{\Delta Y_{i,t-j}} + \mathbf{\Pi Y_{i,t-1}} + \boldsymbol{\eta}_\mathbf{t} + \mathbf{u_{it}} \quad (6)$$

was of full rank. This means that the variables are found stationary and cannot be by definition cointegrated. This allows us to move for the IRF and the identification of matrix A. The residual correlation reveals that *lny* seems to be in a simultaneous relationship with physical capital stock and average years of education (Table A2 in the appendix), which is also what we observed in Section 2. Our identification strategy is based on the observation (derived from a Granger causality test) that a shock in per capita income may affect physical capital but not vice verse, and a shock in average years of education can affect the log of per capita GDP but not the other way around.

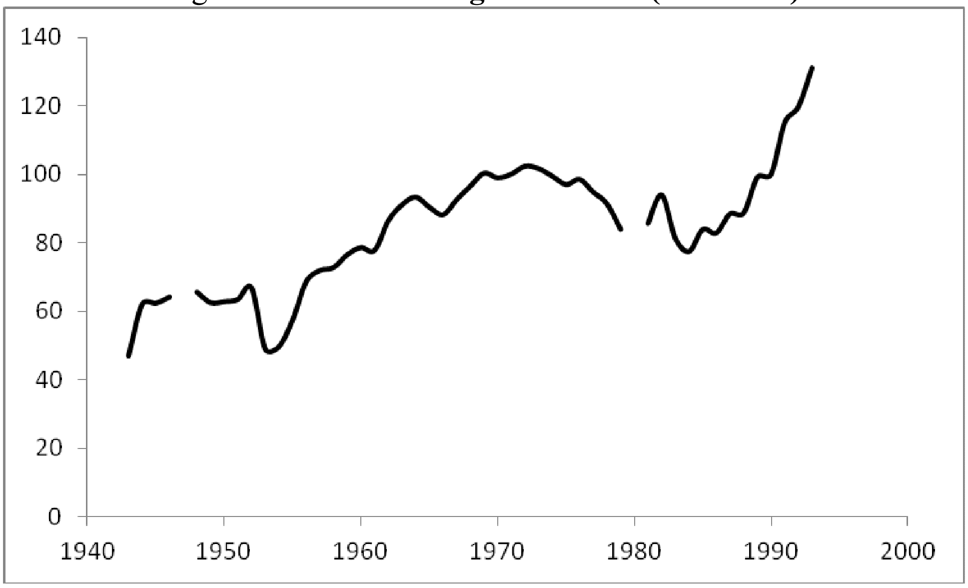
Figure 1. **IRFs and cumulative IRFs from the PVAR**



The Impulse response functions basically confirm what we already learned from the ECM but allow us to gain a better understanding of how education affects per capita income and capital accumulation. Education is affected positively by per capita income, which is an expected result: with an increase in income the share of savings/investments will increase and for less wealthy persons the safest and most profitable investment is in education. Indeed, several studies have confirmed the presence of positive private rate of returns in Africa (e.g. Psacharopoulos and Patrinos 2004). On the other hand education does not seem to have affected per capita GDP neither in the short- nor in the long-run. This means practically the lack of social returns to education. This is not strange given that even for the United States, Acemoglu and Angrist (2001) found social returns until the 1980s to be insignificant.

But is it possible to have positive private returns while social returns are negative of insignificant? However counterintuitive this finding may sound, Pritchett (1997) already discussed this possibility and explained it by the low efficiency of the schooling system, and the structural mismatch between labour market demands and the supply of educational system. Positive private returns may exist simply because of the division of labour and hence it is fundamentally a cross-sectional/cross-individual phenomenon. Some employees will earn more because they have more skills or simply because they are higher in the hierarchy and this very often requires higher educational attainment. Social returns arise only if the marginal product of education is positive. However, wherever increasing education will almost always

Fig. 2 **Index of real wages in Africa (1990=100)**

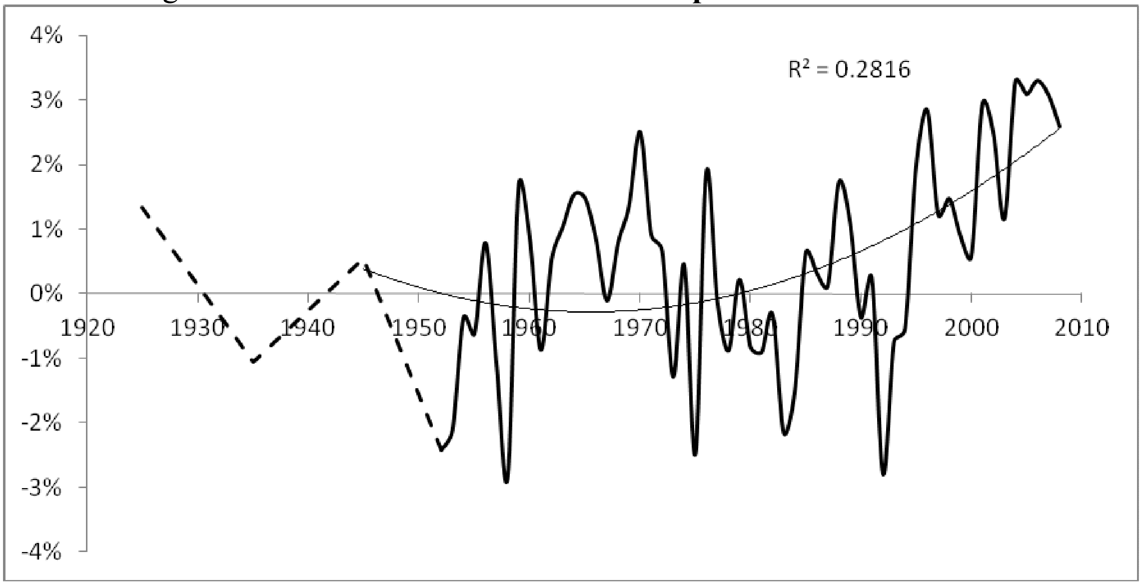


affect the private returns but should not necessarily increase per capita income. This may occur if education increases productivity on individual level (this should take the form of an increase in real wages) and on economy-wide level (through spill over effects). Still, we find no evidence for such effect. Firstly, real wages seem to be growing much slower than per capita GDP until the 1980s, while education on average is even negatively related to per capita GDP growth.

Indirect effects of education in growth may also be present: more educated individuals may be more inclined to save than to consume and it may have a positive effect on physical capital accumulation; according to the IRFs, however, this is not the case in Africa: even though we obtain a positive hump in the IRF for capital stock as a response to a shock in education the magnitude is not high enough to make it significantly different from zero.

Since we also concluded that a shock in physical capital only has a short-run effect on per capita GDP growth, the changes in per capita GDP that can be witnessed in the later 20th century seemingly must have been explained outside the factors of production, i.e. outside of the perspiration factors. Therefore, it is important to look at the inspiration factors, i.e. TFP.

Fig. 3. **TFP as estimated from the ECM specification in Table 1.**



The coefficients of the year dummies from the ECM specification (Table 7) can be interpreted as the trend of the growth of general productivity or Total Factor Productivity (Figure 3). We also added information on TFP growth back to the 1920s based on a growth accounting analysis where we used the coefficients of education and physical capital from the ECM specification and the growth of African GDP, physical capital, and education up to 1950 (see the dashed line in Figure 3). We find the main turning points in accordance with the historical knowledge on the history Africa. An improvement in the last phase of the colonial rule and the 1960s, followed by a decrease until the beginning of the 1990s and an obvious improvement afterwards.

The main conclusion thus seems to be that, at least concerning the last decades, growth in Africa has been mainly driven by inspiration (i.e. TFP growth). However, one may wonder if we cannot find a role for education at least in this general productivity improvement. For

Table 8. **Relationship between the estimated TFP and education**

	TFP	ΔTFP
constant	-0.017 (-3.80)	-0.011 (-2.40)
S_{it-1}	0.006 (3.95)	0.004 (2.66)
TFP_{t-1}	-	-0.626 (-5.01)
ΔS_{it}	-	-0.0097 (-0.44)
R^2	0.205	0.312
DW	1.24	2.05

Note: N=57, period: 1951-1998

this reason we tests for the existence of such a relationship employing a level on level and an ECM specification in Table 8. We find evidence that education had some positive impact on TFP even though it is not possible to find out in this way through which channel this actually happens.

There are basically two ways in which education may affect TFP growth. First, it may improve the technical efficiency of the factors of production, i.e. reduce the diminishing returns to physical capital (and possibly education). Second, it may improve general productivity, i.e. an increase in the level of education increases the maximum possible output per worker. Both factors make up TFP growth: whereas general productivity determines the production frontier (the maximum possible output per person under optimum circumstances), the technical efficiency determines how efficient education and physical capital are (i.e. how far a country is from the production frontier). Hence, in order to analyze how education affects TFP growth, have to decompose TFP growth further in general productivity and technical efficiency.

We take the equations as shown in Van Leeuwen, Van Leeuwen-Li, and Foldvari (2012). They show the role of technical efficiency in TFP as follows:

$$\frac{\dot{y}_{it}}{y_{it}} = \frac{\dot{A}_t}{A_t} + \hat{\alpha}\frac{\dot{k}_{it}}{k_{it}} + \hat{\beta}\frac{\dot{S}_{it}}{S_{it}} + \frac{\dot{u}_{it}}{u_{it}} \quad (7)$$

, where $\frac{\dot{A}}{A_t}$ is TFP growth. If we add technical inefficiency, defined as the difference in coefficient of education and physical capital with the most efficient country, we get:

$$\frac{\dot{y}_{it}}{y_{it}} = \frac{\dot{\theta}_t}{\theta_t} + \alpha_i\frac{\dot{k}_{it}}{k_{it}} + \beta_i\frac{\dot{S}_{it}}{S_{it}} + \frac{\dot{\varepsilon}_{it}}{\varepsilon_{it}} = \frac{\dot{\theta}_t}{\theta_t} + \hat{\alpha}\frac{\dot{k}_{it}}{k_{it}} + \hat{\beta}\frac{\dot{S}_{it}}{S_{it}} + (\alpha_i - \hat{\alpha})\frac{\dot{k}_{it}}{k_{it}} + (\beta_i - \hat{\beta})\frac{\dot{S}_{it}}{S_{it}} + \frac{\dot{\varepsilon}_{it}}{\varepsilon_{it}} \quad (8)$$

Where θ is a time-variant common productivity factor (similar to A in the standard growth accounting in equation (7) but free of the effect of technical efficiency differences, and α_i and β_i are the province specific coefficients. Combining equation (7) and (8) we can show the relationship between TFP growth, general technology growth, and technical efficiency of human-and physical capital as follows:

$$\frac{\dot{A}_t}{A_t} = \frac{\dot{\theta}_t}{\theta_t} + (\alpha_i - \hat{\alpha})\frac{\dot{k}_{it}}{k_{it}} + (\beta_i - \hat{\beta})\frac{\dot{S}_{it}}{S_{it}} \quad (9)$$

In other words, TFP growth consist of the growth of general productivity (i.e. the outward movement of the productivity frontier) plus the difference in productivity of each factor of production compared to the most productive country (i.e. technical efficiency of the factors of production).

We can make this decomposition by using the ECM specification from Table 7 and add cross-effects with country dummies for both education and physical capital. The year dummies than represent a trend in general productivity growth (Figure 5) while TFP growth (Figure 3) minus general productivity growth results in the growth of technical efficiency of the factors of production (see Figure 4).

From Figure 4 and 5 t becomes clear that technical efficiency growth was virtually zero until the 1960s, i.e. an increase in education or physical capital does not lead to

Figure 4. **Growth in technical efficiency**

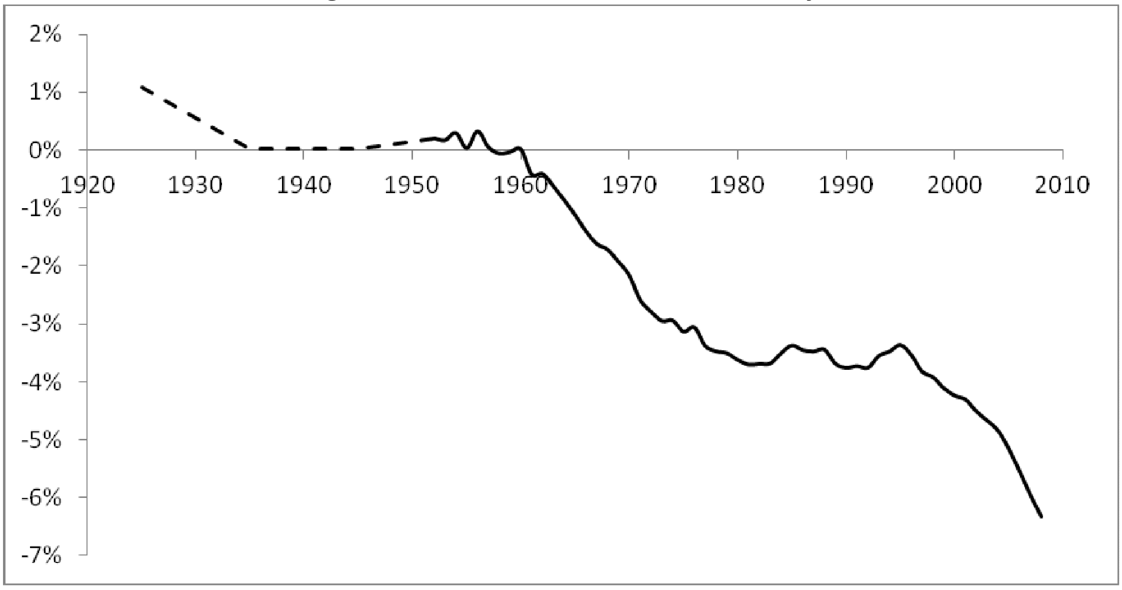
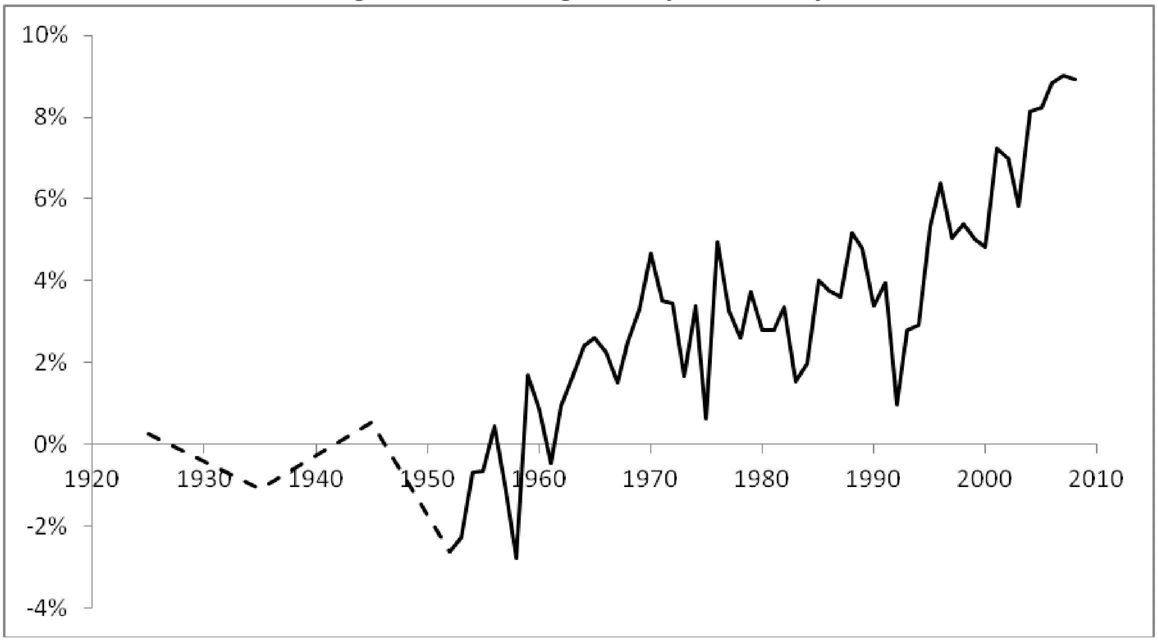


Figure 5. **Growth general productivity**



diminishing returns. This all changed in the 1960s, followed by a further dip in the 1990s. Since, as we have seen, TFP growth increased after the 1960s, this implies that, after subtracting technical efficiency, general productivity is even increasing faster over time. This is indeed what we may observe from Figure 5: after 1960 there is a clear increase in general development, followed by an even faster increase in the 1990s.

In order to test if education affects TFP growth via increasing the growth of technical efficiency, or by increasing the growth of general productivity, we follow Mahadevan (2007) in running a Granger causality test. We find that there is only a weak link between the perspiration factors (physical capital and education) and inspiration: only education has a small negative effect on general productivity. However, this effect is offset by the strongly positive effect education has on technical efficiency. This is not surprising as an increase in

Table 9. **Granger causality tests**

effect	average effect p-value	verdict	sign relation
k affects technical efficiency	0.013	yes	-
technical efficiency affects k	0.952	no	NA
k affects general technology	0.058	no	NA
general technology affects k	0.007	yes	+
educ affects technical efficiency	0.010	yes	+
technical efficiency affects educ	0.674	no	NA
educ affects general technology	0.032	yes	-
general technology affects educ	0.046	yes	-

physical capital requires an increase in education to become productive, i.e. skill biased technical change. This is also the reason that an increasing in physical capital leads to a clearly negative effect on technical efficiency.

From the perspective from the inspiration versus perspiration debate, our findings for Africa are very interesting. First, we do find that per capita income drives physical capital and education rather than the other way around. Only physical capital has a short-run effect on per capita income. This were to suggest that most of Africa's growth is caused by inspiration, i.e. TFP growth. Indeed, decomposing TFP growth into technical efficiency of the factors of production (i.e. how far countries are from the productivity frontier) and general productivity (i.e. where the productivity frontier is located), we find especially the latter drives most of African growth. This has two important consequences. First, this suggests a large unused potential (i.e. low technical efficiency) compared to Southeast Asia. It is here that we find that human capital does play a role by increasing technical efficiency, which makes it profitable to add more physical capita to the current stock. Second, it implies an increasingly larger inequality within Africa (since some countries are much more productive than others). It is this latter factor, and the effect on education on it, that we are going to discuss in the following Section.

4. Does education help to ease income inequality?

In the previous Section we found that one consequence of the outward shift in general productivity combined with a decrease in technical efficiency was an increase in inequality within Africa. Education may affect income inequality through two channels. First, a higher level of education may increase the level of average income, which, ceteris paribus, reduces income inequality.[3] This channel does not seem very likely to work for Africa though as we

[3] To see why, it is instructional to turn to Milanovic (1997) who derives the relation between the Gini coefficient and the Coefficient of Variation (CV), which is the standard deviation divided by the mean. Ceteris paribus, if the CV increase by 1 unit the Gini coefficient will increase by $\frac{1}{\sqrt{3}}$ unit.

saw in the previous section. Another possible mechanism is the effect of educational inequality that may work even if the first channel is not present. This has been explored by Knight and Sabot (1983) and is very likely to lead to a non-linear relationship. A more equally distributed educational stock will affect income inequality through two ways: first, the composition changes will assure that there will be more educated workers reducing earning differentials, second, with a change in the supply of skilled workers, wages will be compressed. This latter effect requires, however, that wages are a function of educational attainment.

Even though little evidence is available on long-run inequality in Africa, fortunately, Van Zanden et al. (2011) have created a long-run dataset with Ginis for African countries for benchmark years between 1820 and 2000. Their dataset, however, makes use of the Maddison GDP estimates to proxy between country inequality. Likewise, their Tables do not report all data for Africa, but rather for Africa minus the Northern African countries. Therefore, we add the GDP per capita estimates from Prados de la Escosura (2011) (since those estimates are on average not much different from our own calculation and are available for each country separately) for 1929, 1910, 1890 and 1870, and we add the inequality estimates for the Northern African countries. The results are reported in Table 10.

Table 10. **Income inequality in Africa, 1870-2000**

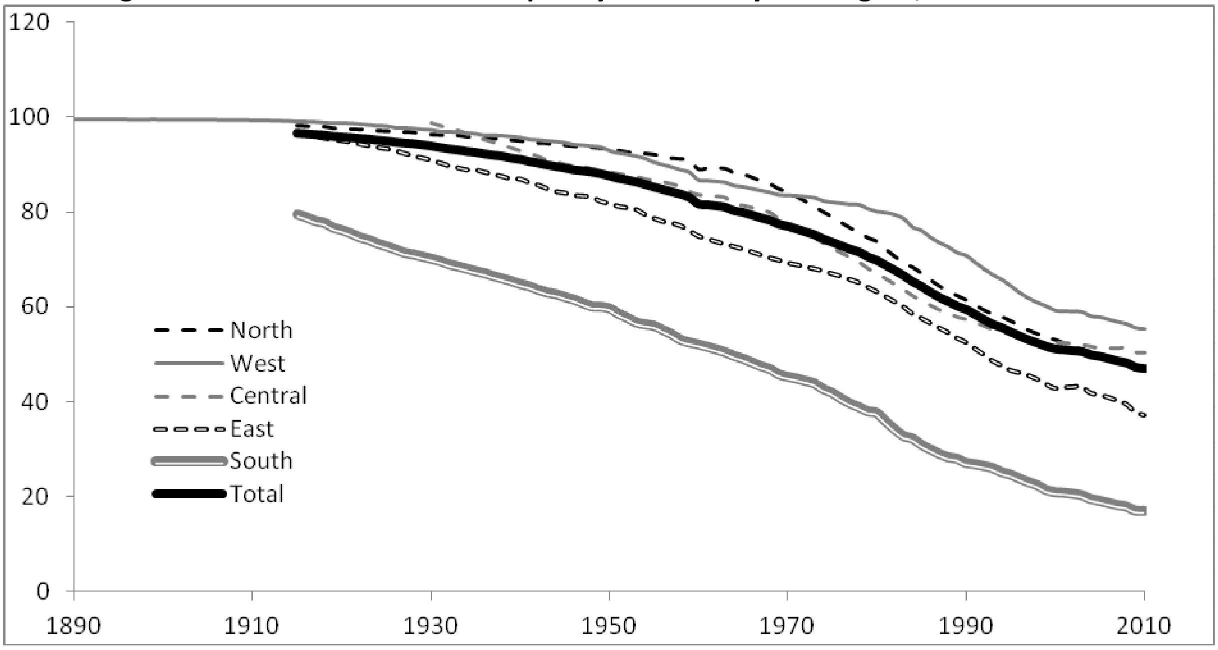
	Within country inequality (a)	Between country inequality (b)	Sum column a+b (c)	Overlap factor (d)	**Total inequality (e)**
1870	0.48	0.25	0.73	0.21	**0.52**
1890	0.35	0.24	0.59	0.19	**0.40**
1910	0.41	0.25	0.65	0.18	**0.47**
1929	0.47	0.26	0.72	0.18	**0.54**
1950	0.42	0.29	0.71	0.19	**0.53**
1960	0.52	0.30	0.81	0.22	**0.60**
1970	0.48	0.32	0.80	0.24	**0.57**
1980	0.46	0.36	0.82	0.26	**0.56**
1990	0.47	0.37	0.84	0.27	**0.57**
1995	0.47	0.38	0.85	0.27	**0.58**
2000	0.50	0.40	0.89	0.29	**0.60**

Interestingly, Africa turns out to the only continent where within country inequality actually rises after 1890. A similar rise may be observed for between country inequality and, consequently, also for over-all inequality. Whereas the rise in between country inequality is a worldwide phenomenon, the rise of within country inequality is not. Even though this rise in within country inequality takes place in all African regions, it turns out to be particularly pronounced in Southern Africa, which is also the region with the highest per capita income.

Unfortunately, as argued in the previous Section, we found very little evidence that education is directly driving per capita income. Yet, income did drive educational development. This implies that average education may be higher in the richer areas (i.e. Southern Africa and North Africa after 1970) and, consequently, that educational inequality is lower in these areas. The second way in which education may affect income inequality, though, was via educational inequality: if education increases, it will increase initially increase income inequality since an increasing number of people get education but the majority still does not. Even though this increase in the number of educated people may press down the skilled wages, the former effect dominates and income inequality will rise. Only after the majority of the persons had access to education, i.e. educational inequality declines, we expect income inequality to decline. In order to analyse these effects of education on inequality, we need first to have estimates of educational inequality. We use the method as described in Thomas, Wang, and Fan (2000), Checchi (2004) and Castelló and Doménech (2000, 4).

The results of educational inequality are reported in below graph. It is important to stress that these results are weighted: when a country drops out, the most resembling country

Figure 6. **Gini of educational inequality in Africa by sub-region, ca. 1890-2010**



in terms of educational inequality in its group gets the weight of the omitted country. This is very important since the best data for the earlier periods are for those countries with the highest level of education and, consequently, the lowest educational inequality. Again, we find that the South does much better (i.e. lower) in educational inequality, while the North only starts to decline from the 1970s onwards, when their per capita income started to grow. This once more confirms that education does not increase average income and, as such, lowers income inequality, but rather the other ways around.

This leaves us with the explanation that a rise in educational inequality may lead to a rise in income inequality. This may be true irrespective of average income, since existing private returns do not necessarily mean existing social returns. Hence, using the data on educational and income inequality, we explore in Table 11 the relation among income inequality, educational attainment and educational inequality. Due to the presence of possible simultaneity, we also employ a 2SLS regression with lagged values of the potentially endogenous variables as instruments and the growth rate of population as instrument for the

Table 11. **Income inequality explained by education inequality and educational attainment**

	income inequality	income inequality (2sls)
constant	20.29 (0.86)	81.93 (0.78)
S_{it}	3.24 (1.71)	6.46 (1.19)
educ ineq	1.561 (3.21)	1.932 (2.67)
educ ineq squared	-0.021 (-2.35)	-0.022 (-1.80)
educ ineq cube	0.0001 (2.12)	0.0001 (1.67)
$\ln y_{it}$	-3.34 (-0.91)	-16.2 (-0.84)
R^2	0.693	0.607
N	183	179
Sargan test	-	0.201 (p-value=0.347, d.f. =1)

Note: instruments: population growth rate, fifth lags of education ineqality and its square and cube, fourth and fifth lags of education.

per capita income (this choice is motivated by the Solow model).

Even after the instrumentation, we find no significant change in the results. We find a non-linear relationship between income and educational inequalities. Not surprisingly, we find that the coefficient of the level of average years of education remains insignificant. This result was expected since we found no relationship between income level and educational attainment on macro level. But how much improvement in income inequality could be achieved by reducing educational inequality? The mean of the educational Gini in 2010 was 45.35. If this were reduced to zero, based on the coefficients in table 3, this would reduce income inequality by 36.9, which is a quite big effect (the mean within-country income Gini in 1990 was 47).

5. Conclusion

In this paper, we tried to address the issue how education affect economic welfare. This was motivated by the theoretical observation from many theories that it is education (and ultimately human capital) that drives economic development. However, we find that, except for a short-run effect of physical capital, neither education nor physical capital affects per capita income growth. Yet, as may be expected, an increase in income does affect education and physical capital.

These findings seem to suggest that it were inspiration (i.e. TFP) rather than perspiration (i.e. education and physical capital) factors that drove economic development. Yet, TFP can be subdivided in the growth of general productivity (i.e. a productivity frontier that indicates the maximum possible productivity per capita), and technical efficiency (i.e. how efficient education and physical capital are [how far they are from the technical frontier]). We find that education does have a positive effect on technical efficiency (whereas physical capital has a negative effect) implying that education is necessary to adopt skill biased technology in the productive process. This leads to a small, but significant, effect of education on TFP growth.

Yet, it remains clear that it is largely productivity growth, rather than anything else, that drives African economic growth. Combined with a decrease in technical efficiency (i.e. more countries stay further from the productivity frontier) this implies a strong increase in inequality in Africa. Does the low effect of education on per capita income means that education is not a good policy tool to address inequality?

We argued that there are basically three ways in which education may affect inequality. First, an increase in the level of education increases average income, which, ceterus paribus, reduces inequality. This has clearly been rejected since we hardly found any effect of education on per capita income. Second, a rise in education may reduce educational inequality. Since the private returns to education are positive, this suggests a reduction in income inequality. Thirdly, an increase in education may increase the supply of education and, as a consequence, lower the price of skilled labour, i.e. lowering income inequality. Testing the latter two effects, we found there was indeed a strong, non-linear, relationship between educational and income inequality. We found that, in 2010, reducing educational inequality to zero implied a decline in income inequality by no less than 81%.

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Appendix

Table A1. **Im, Pesaran and Shin unit-root tests (individual unit-root processes and individual effects are assumed)**

lnyit	lnkit	Sit
1.928 (0.973)	1.343 (0.910)	2.948 (0.998)
Δlnyit	Δlnkit	ΔSit
-36.62 (0.000)	-7.906 (0.000)	-5.565 (0.000)
Δ2lnyit	Δ2lnkit	Δ2Sit
-59.03 (0.000)	-47.86 (0.000)	-52.88 (0.000)

Note: p-values are reported between parentheses. H0: non-stationartiy

Table A2. **Residual correlations form the VAR(9) specification**

	lny	lnk	S
lny	1		
lnk	0.191 (0.000)	1	
S	-0.042 (0.069)	0.019 (0.398)	1

Note: p-values are reported in parentheses