UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Effects of Education on Sub Saharan Africa

Wei Pei Juliana Wong

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Supervisor: Måns Söderbom

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1. Introduction

Over the last decade, Africa has shown commendable economic growth. Out of the world's ten fastest-growing countries, six countries were African. Africa has grown faster than East Asia, including Japan in eight of the past ten years. Africa is expected to grow by 6% in 2012, about the same as Asia (The Economist, Dec 3rd 2011).

In 1957, Michael Scott, a founder of Africa Educational Trust, addressed the United Nations, noted that education is the key to development. This belief has been reiterated for the last fifty decades. In 2000, at the World Education Forum, in an unprecedented effort to provide free primary education for every child, universal primary education (UPE), a Millennium Development goal, was established. Ever since, Sub-Saharan Africa (SSA) has done quite a bit to expand education. A 2011 report by UNESCO Institute for Statistics shows that real expenditure on education has increased by 6% yearly across SSA in the last ten years. The resources used ensured greater enrolment and improvement of the educational services. The effort paid off in terms of increased number of children in primary schooling by 48% and increased enrolment in primary, secondary and tertiary education by over 60% between 2000 and 2008. In fact, there has been a rapid growth of enrolment at all levels of education especially since the 1970s (Seetanah 2009).

Despite some progress, the result has been dismal for Africa. Africa Progress Report 2011 shows that the performance ratio is only 52% on the UPE goal. Many SSA countries trail behind the UPE goal. About 50% of all children do not complete primary education in one-third of SSA countries. Secondary and tertiary intake rates in SSA are very low.

In the wake of UPE and low increase in secondary and tertiary enrolment rates, recent research focuses on the trade-off between more resources allocated to primary education and higher post-primary education on Africa's economic growth. It has been argued the lack of access to higher education will hamper growth in African industrial sector. Africa's large and growing skills gap has become a key concern and poses a real threat to Africa's industrial development and eventually growth (Page, 2010).

This paper aims to study the effect of education at primary, secondary and tertiary levels on economic growth for sample of 33 SSA countries for the period between 1960 and 2010. Furthermore, the paper seeks to determine how important is the effect of education on the growths of various sectors deem to be the drivers of SSA economic development and growth.

This paper departs from previous literature on three main areas. First, rather than just looking at the effect of changes in the overall education on growth, we break down the overall education into primary, secondary and tertiary levels and estimate the effects of the changes in education at the three levels. Second, we also estimate the effects of education on the growth rates of SSA various sectors – agriculture, industry, service, manufacturing and construction. Finally, we attempt to take into account the quality of education. Data used in this paper comes mainly from data obtained by Barro and Lee (2001). In fact, they have recently updated their data on educational attainment such that it now spans over the period between 1960 and 2010. Also, their dataset contains information on education for both population age 15 and above and population age 25 and above.

The next section, Section 2, reviews the literature which discusses the effect of education on economic growth as well as the theoretical models (such as the augmented Solow model and macro-Mincer equation) which attempt to estimate the effect of education on growth. Section 2 also reviews the empirical relationship between human capital and economic growth in Africa in general. Finally the section also brings to light the growth skills gap problem in Africa. Section 3 relates the Mincerian wage equation to the macro growth model. The section also extends the basic macro-Mincer model for the purpose of our study. Section 4 discusses the data and describes the statistics. Section 5 explores the findings of the empirical results. Finally, Section 6 concludes our study.

2. Literature Review and Theoretical Models

The paper investigates the effect of *the change* in education at primary, secondary and tertiary levels on (i) economic growth, and (ii) the growth of key sectors in Sub-Saharan Africa. There is scant literature which study the relationship between education and economic growth for developing countries (Seetanah, 2009), especially Sub-Saharan

Africa. Most macro level research has been based on the US and other OECD countries largely.

To begin with, the expected positive relationship between education and economic growth is not strongly supported by empirical evidence. The existing literature produces mixed empirical results of the effect of education on economic growth (Seetanah 2009). By contrast, the private rate of return to education on an individual's wage is consistently estimated to be positive. It is widely acknowledge that education can contribute to economic growth because social returns to education are likely to be higher than the private returns. The divergence between the social and private returns is due to the positive externalities to education which is also what motivate the macro growth literature. Positive externalities to education may arise when higher education contributes to technological progress that is not captured by the private return to that education (Nelson and Phelps 1966). However, some literatures have also argued that it is also possible that social return to education is lower than the private return (Krueger and Lindahl, 2000). This could occur because education is just a certification which does not increase a person's productivity. In addition, in developing countries, increases in education may cause unemployment rate to increase, and the return to physical capital may be greater than the return to human capital. As a result, increases in education may lead to lower total output (Krueger and Lindahl, 2000). The interest in the externalities to education is what drives most macro growth literature and is what we will discuss now.

There are two main growth theories: neoclassical growth models and endogenous growth models. Neocalssical growth models assume that productivity growth is exogenous. On the other hand, new growth theory proposes that long-run economic growth is determined more resources devoted for education and innovation. Human capital is treated as an additional input. In a neoclassical growth model, human capital contributes to equilibrium production levels. In an endogenous growth model, human capital affects the balanced growth rate. Human capital also facilitates the adoption and absorption of new technologies and thus contributes to productivity.

2.1. Neoclassical growth theory

It is useful to first look at the standard neoclassical growth model by Solow (1956). The theory assumes a production function of the form

$$Y = Af(K, L)$$

where Y is output, A is total factor productivity (TFP), K is physical capital, and L is labor. Labor productivity is defined by Y/L while changes in TPF (A) represent technological change (Hicks neutral). The rate of technological progress and the growth rate of labor force (affected by population growth) are unexplained or exogenous and determine long-run economic growth (hence, *exogenous growth*). The Solow model predicts conditional convergence, that is, conditional on savings rates and population growth rates, poorer countries tend to growt faster than richer ones.

2.2 Human capital in a neoclassical model

Although the Solow model correctly predicts the signs of the coefficients on saving and population growth, the Solow model is not completely successful. The esitmated impacts of sainvg and population growth are much larger than the model predicts. This is because human capital, an important variable, is missing in the neoclassical framework. The human capital theory by Schultz (1961) and Becker (1964), suggests that education increases a person's skill level and thus his human capital. A more highly-skilled labor force increases the production capacity.

The augmented Solow growth model introduces human capital. Mankiw et al. (1992) suggest a Cobb-Douglas production function of the form $Y = K^{\alpha} H^{\beta} (L)^{1-\alpha-\beta}$ where H is the stock of human capital of the labor force, α is the output elasticity of physical capital, β is the output elasticity of human capital ($\alpha + \beta < 1$ i.e. decreasing return to all capital to maintain exogenous balanced growth), and $1 - \alpha - \beta$ is the output elasticity of labour. Mankiw et al. use enrolment rates to proxy H. Alternatively, the macro-Mincer equation model determines the human capital stock H based on the form of $H = e^{\pi(s)}$ where s is average years of schooling. A key implication of the extended (augmented) Solow model is that an increase in the average years of schooling (a proxy to the average skill level) in the labor force increases the human capital stock H, and thus the output level Y. Because an increase in human capital only raises output levels, but has no permanent effect on the balanced growth path, long-run economic growth is considered *exogenous* to human capital.

2.3. Human capital and endogenous growth model

Human capital is an essential input in endogenous growth models (e.g. Romer, 1986; Lucas, 1988). Lucas (1988) treats human capital as just another input like physical capital in the standard neoclassical model. Lucas (1988) introduces growth to human capital accumulation. Human capital is accumulated through schooling (learning-or-doing) and experience (learning-by-doing). The human capital accumulation technology is considered a structural parameter that determine long-run economic growth rate. Hence, growth is thought to be *endogenous* to human capital. In the absence of external effects, increases in human capital merely lead to higher wages. Thus, Lucas model does not support that education will have a positive impact for growth. However, when Lucas allows the model to take into account of human capital externalities, there is a divergence between the private and the social marginal product of human capital. Consequently, in a free market, there will be underproduction of human capital from society's viewpoint.

2.4. Time lag in the effect of human capital

There is a time lag between the investment in human capital and the time when the human capital becomes suitable for production. This time lag is important at two levels. First, the time lag is affected by the schooling level. On one hand, an increase in tertiary education enrolment will lead to a higher percentage of skilled workers in the labor force after four to six years. On the other hand, an increase in primary education enrolment will impact on the labor force after ten to fifteen years (Canton etc., 2005). Second, an extension of the schooling period takes a long time (about 50 years) to change the average educational attainment of the labor force.

2.5. Human capital and technology adoption

As explained earlier, based on Lucas (1988) endogenous growth model, the *accumulation* of human capital over time sustains economic growth. In other words, the changes in human capital stock, i.e. ΔH matter for the changes in output. Alternatively, some literatures support it is a country's *stock* i.e. H of human capital that determines the rate of economic growth. For example, Romer (1990) assumes that human capital stock produces innovations. Thus, his model implies that a country with a larger total human capital stock will enjoy faster growth. In another example, Nelson and Phelps (1966) assume that the human capital stock facilitates technological progress and diffusion and determines the ability to adopt new technologies. Thus, the level of human capital matters for the growth rate of output. To incorporate the notion that human capital contributes to the ability to assimilate technologies, the level of total factor productivity is linked to the human capital stock, i.e. $A = A(H)$ with $A' > 0$.

The bone of contention is whether it is the human capital *stock* or its *accumulation* that matters for growth and this is an empirical question. In the model, I therefore allow for the effects of both the stock and the changes in human capital – the increases in the average educational attainment of the population – and estimate how these would effect on growth rates.

2.6. Relationship between human capital and economic growth: Macro level Evidence

Krueger and Lindahl (2000) highlight two key conclusions from macro growth literature. First, the initial stock of human capital, not the change in human capital, affects growth. Second, secondary and post-secondary education rather than primary education affect growth. Yet there is no consensus about what level of education has a positive effect on the growth of income. Nelson and Phelps (1996) and Romer (1990) emphasize that higher education such as research and development drive growth. On the other hand, it has also been argued that primary education is the main source of growth, especially for less developed countries (Gyimah-Brempong, 2005; Gemmell, 1996).

Our paper aims to contribute to the existing literature in three areas. First, we establish the relationship between the change in human capital and growth. Because the new educational dataset by Barro and Lee (2011) is available only recently, our study is unlike previous literatures which could only make use of Barro and Lee (1996) earlier education data for the population aged 25 and over at five-year intervals from 1960 to 1985. So we can exploit the new data to estimate the effects of change in education spanning over longer time periods, say 10 and 20 year changes. Due to measurement error in schooling data, the time span affects the estimates for the effects of the change in education (Krueger and Lindahl, 2000). Second, few literatures have looked at the changes in education for all three levels, primary, secondary and tertiary education. Our paper decomposes education so as to determine which of these three levels of education has been most important for SSA growth and thus answer the question whether UPE is the key answer to SSA progress. Third, our paper also analyzes the growth of various sectors in addition to overall economic growth. This is to shed some light about the importance of higher education on SSA's growth of industry or industrialization. Finally, we attempt to account for the quality of education by using proxy pupil-to-teacher ratios (Barro and Lee 2001; Sequeira and Robalo 2008) which previous papers ignore due to lack of data availability.

2.7. Growth accounting framework and Level effects

It is crucial to distinguish between the levels and the changes of the human capital stock. In equilibrium, the stock or the *level* of human capital stock affects a country's output (GDP) level, but not the economic growth rate. On the other hand, changes in the human capital stock are expected to have a positive effect on economic growth during the transition period.

The economic models[1] explain how the human capital stock affects the output level, or in first differences, the changes in the human capital stock affect growth. As mentioned in Section 2.2, Mankiw et al. (1992) estimates the augmented Solow model with human capital. Human capital is measured by using the percentage of labor force enrolled in secondary education (the authors do not consider primary and tertiary education). Their result shows that the fit of the model improves when human capital is included.

[1] The study of economic growth has divided the macro level research into two camps: growth accounting and growth regression frameworks. Growth accounting or *structural* approach is to derive the econometric model based on a theoretical model. The level effects and the growth effects of the human capital are considered separately (Canton et al., 2005).

Moreover, their estimation result implies that the output elasticity of human capital is 1/3. This means the human capital stock (level) is found to affect positively a country's output level. However, Mankiw et al. do not find concrete eveidence for the positive relationship between changes in human capital and economic growth for all the three country samples in their study (for example, the relationship between human capital accumulation and GDP growth is not significant for the OECD countries).

While the Mankiw et al. model aims to test the Solow model and the conditional convergence hypothesis so as to explain the differences in income levels across countries, our model in this study focuses on the effects of investments in human capital on the rate of ecoconmic growth. Consequently, the variables capital K and labor L are not included in our model. Moreover, the inclusion of capital is problematic and is discussed briefly in Section 2.9.

2.8. Growth accounting framework and Growth effects

The growth accounting approach attributes output growth to two components – input growth and a 'residual' which captures efficiency change and is not explained by inputs. Educational attainment is an example of input. Hence, this method can be used to quantify the proportion of output growth due to increases in educational attainment.

Benhabib and Spiegel (1994) use cross-country estimates of physical and human stocks to run the growth accounting regressions based on a Cobb-Douglas aggregate production function. They find that human capital is insignificant (and negative) as a determinant of per capita growth rates. The log difference in human capital is always insignificant and its coefficient negative. Benhabib and Spiegel propose an alternative model implied by endogenous growth theory in which the growth of total factor productivity is a function of the level of education or human capital. However, it is cautioned that there may be a misspecification problem if human capital is treated as another factor in growth accounting.

The alternative model follows Romer (1990) which proposes that human capital has a *direct* effect on productivity because it enables countries to innovate new technologies to suit domestic production. The model also follows Nelson and Phelps (1996) so that human capital levels can affect the speed of technological catch-up and spread. Thus, the ability of a country to adopt new technology from abroad for domestic production is assumed to be a function of its own human capital stock. Benhabib and Spiegel show that the human capital level affects GDP growth positively. A 1% increase in human capital stock leads to 0.13% increase in the growth rate. They also find that countries with more human capital stock enjoy faster technological catch-up. Poor countries benefit from more human capital stock due to only adoption-effect. Barro and Sala-i-Martin (1995) also find that education aids technology catch-up and that larger initial human capital stock speed up catch-up growth.

2.9. Growth regression framework

While growth accounting models are limited by the restriction of the parameters of the aggregate production function, growth regressions or macro regressions make use of cross-country variation in the data to estimate directly the productivity effect of education in the GDP growth equation (Krueger and Lindahl, 2000). Barro and Sala-i-Martin (1995) pioneer this approach and find that primary education of males and females have no significant effect on growth, although the result could be due to misspecification (Krueger and Lindahl, 2001). The misspecification is due to their log specification of education. The log-log specification is valid if schooling is assumed to enter an aggregate Cobb-Douglas production function linearly. However, the success of the Mincer model implies that human capital is expressed as an exponential function of schooling in a Cobb-Doublas production function. This means that the change in linear years of schooling would be specified in the growth equation. The advantage of the growth regression framework allows new independent variables that are previously ignored by the theory. However, the technique of adding independent variables deem important is ad hoc.

Krueger and Lindahl (2000) discuss the key issue of controlling physical capital: to include capital or not in GDP growth equation. Capital-skill complementarity suggests that increased capital explains some of the increased output due to higher education. Education affects output growth directly and indirectly. It is shown that most of the effect of the change in education education on output growth is through increased capital. The direct effect of the change in education is very little and insignificant (Krueger and Lindahl, 2000). Consequently, including capital takes away much of the indirect effect of education on growth and leads to the estimation of only the direct effect of education.

But problems arise when adding the growth of capital in GDP growth regression. The problems are systematic correlation between measured capital and GDP (i.e. including the capital takes away much of the effect of education on growth) and the endogeneity of capital. The systematic correlation between measurement errors in capital and GDP occurs because capital is measured by using investment flows, and investment is a component in GDP function, so errors in the investment data will be positively correlated with the dependent variable GDP. The endogeneity of capital refers to the simultaneity bias problem because it is possitlve that countries with high GDP growth undertake more investment.

2.10.Empirical relationship between human capital and economic growth: Africa and Sub Saharan Africa

Pritchett (1996) finds that SSA accumulated more educational capital than did other regions in the last thirty years. Africa's labor force saw a faster percentage rate increase in the educational attainment than other regions (even East Asia) due to its initial low base. But Africa's absolute growth in years of schooling is also twice as great that of other regions. However, the growth of GDP per worker in SSA was the least compared to other regions. Pritchett (1997) shows that the relationship between growth in education and growth of output per worker is barely evident. He finds that the educational capital has negative and insignificant effect on the growth rate of output per worker. Gyimah-Brempong *el at.* (2006) also find that the relatively large growth effect of higher education human capital may be due to the very low stocks of higher education human capital in Africa. Consequently, the additional higher education human capital contributes more to income growth.

Gemmell (1996) predicts growth of primary education may have a significant effect on GDP growth in low-income developing countries which rely on primary education as a big source of human capital accumulation. On the other hand, primary education may have no effect in high-income developed countries where almost everyone has primary education and where secondary and tertiary drive the bulk of human capital accumulation. His result shows that both initial stocks and subsequent growth of human capital have a positive effect on income growth. A 1 percent increase in tertiary human capital stock leads to a 1.1 percentage point increase in per capita GDP growth rate. Primary and secondary levels more important for low- and higher-income developing countries respectively, but tertiary level for developed countries.

2.11. Quality of education

It is hard to compare education data across countries. For example, one year of schooling in, say, Malawi is not equivalent to one year of schooling in South Africa. Barro (1991) attempts to measure the differences in the quality of education across countries and so includes student-teacher ratios (in the initial year 1960) in the regression. The ratio for primary schools has a significant and negative on economic growth. This result is in line with the logic that a higher pupil-to-teacher ratio indicates lower quality education and hence, a lower initial stock of human capital. Barro and Sala-i-Martin (1995) find an increase in public spending on education as a share of GDP increases the annual growth rate. Controlling for the years of schooling, the expenditures on education as a share of GDP may be a proxy for the quality of education.

In a panel data set for a broad number of countries, Barro and Lee (1997) show the determinants of educational quality are family inputs and school resources and are closely related to school outcomes. The school outcomes are measured by internationally comparable test scores, repetition rates and drop-out rates. Family inputs refer to mainly family income and parents' educational level. For example, parents who are highly educated are likely to demand more education and ensure more educational materials and activities provided for their children. More family income allows children to have better nutrition and thus learn better. The real per capita GDP is used as a proxy for parent's income while the average primary schooling years of adults aged 25 and above serves as a proxy for education of parents. The variables for school resources are pupil-teacher ratio in primary school, real public educational spending per student in primary education, real salary per primary school teacher and the length of the primary school year. Their results indicate that parents' income and educational attainment have a strong positive effect on children's academic performance. Smaller class sizes, higher teacher salaries and spending per pupil have found to significantly improve test scores.

Sequeira and Robalo (2008) replicate the results in Barro and Lee (2001) to confirm that both background (income and education) and inputs are important measures of school quality. Furthermore, they do not find that teachers' salaries and expenditures *as a proportion to GDP per capita* are significant. However, pupil-teacher ratio is e an important input for ensuring school quality. Moreover, when fixed-effects are considered, GDP is the only consistent significant determinant of school quality.

2.12.The growing skills gap problem

Amid the effort to meet the UPE target, Africa's problem of large and growing skills gap has surfaced. Between 1990 and 2002, Africa increased its secondary enrollment rates by 7% and its tertiary rates by a mere 1%. These figures are very much lower than East Asia's progress of 21% and 12% for secondary and tertiary rates respectively (Page, 2010). Between 1999 and 2009, SSA has improved its net secondary enrollment rate (NER) by a commendable 8.3% (from 19% to 27%), but has still the lowest NER of all the regions and is about 30 behind the rest with NERs (The World Bank). SSA fares the worst among all the regions for gross tertiary enrollment rates (GER) with 3.9% of youth enrolled in 1999 and 6.3% in 2009. A 2007 World Bank reports that the quality of tertiary education has declined (Ethiopia) due to exodus of qualified professors in higher institutions as a result of brain drain, inefficiency and poor governance (Hassan and Ahmed, 2010). Furthermore, employer surveys indicate that African tertiary graduates are weak at solving problem and comprehending business and have poor computer and communication skills (Page, 2010). An example is Rwanda where a mere 5.7% of the local labor force has tertiary education. Skilled labor is scarce and educated workers cannot think independently and critically. Many Rwandan businesses do not understand the concept of bulk discounts, and charge high prices for large orders. Hence, small business like second hand clothes and cafes are absent in Rwandan countryside (The Economist, Feb 23rd 2012).

Page (2010) warns that the lack of access to higher post-primary education will impede the development of Africa's industrial sector. First, recent cross country empirical study shows that there is a strong relationship between export sophistication and the percentage of labor force that has completed post-primary education. Second, there is also some evidence that indicate business firms run by university graduates in Africa tend to have higher propensity to export. More general evidence suggests that indigenous firms with entrepreneurs that are university educated tend to have higher growth rates.

There is a general consensus that Africa has to ensure that higher education is available, an area which Africa trails far behind Asia. A common grouse among African businessman is the shortage of skills and qualified workers are expensive to hire. If Africa does not ensure more access to higher education, it would be hard for Africa to replicate the Asian miracle growth (The Economist, Dec 3rd 2011).

3. Methodology

To show the appropriate model for estimation in our study, we first explain the micro Mincerian equation and then relate it to the macro-Mincer equation (Krueger and Lindahl, 2000).

Mincer's model of earnings (1974) is the standard framework that is used to estimate the statistical relationship between wages and education (or schooling). For a cross section of workers, Mincer (1974) regresses log wages on years of schooling and experience. The log specification is used because it fits the data better than a regression of the level of wages on the years of schooling and experience. The Mincerian model is given by Equation (1)

$$\ln W_t = \beta_0 + \beta_1 Schooling_t + \beta_2 \exp_t + \beta_3 \exp_t^2 + \varepsilon_t \qquad (1)$$

where ln Wi is the natural log of the individual wage. $Schooling_t$ is a linear term in years of schooling and $\exp_t$ and $\exp_t^2$ are the linear and quadratic terms in years of labor market experience. The coefficient of interest, β_1, is the rate of return to investment in schooling. The Mincer's model allows the time spent in school to be the key determinant of earnings, so that data on years of schooling can be used to estimate the return to education across countries with different education systems for easy comparison. For most countries in the world, Psacharopoulous (1994) estimates the returns to education based on Equation (1) and shows that the Mincerian rate of return estimate of β_1 range from .05 to .15.

However, some caution is required to interpret β_1 estimate. It has been argued that the ability of a person affects a person's education. A person who is, say, more intelligent is likely to invest in higher education. However, this ability characteristic is unobserved and ends up in the error term ε_t. The correlation between $Schooling_t$ and unobserved ability in the error term produces a bias in OLS estimate of β_1. A simple way to address the ability bias is to use an instrument that is correlated with the measure of schooling and uncorrelated with the unobservable ability.

The interest in the macro growth literature stems from potential externalities to education. Equation (1) is summed across individuals each year using the means of each variable. The experience variable is dropped for convenience because it is hard to measure experience across countries. Equation (1) then becomes the macro-Mincer wage equation:

$$\ln Y_{jt} = \beta_{0jt} + \beta_{1jt} H_{jt} + \varepsilon_{jt} \tag{2}$$

where Y_{jt} is the geometric mean wage and H_{jt} is mean education for each country *j* and time period *t*. The macro Mincer equation (2) is differenced between year *t* and *t-1*. Taking first-differencing eliminates the additive individual effects due to, say, permanent differences in technology.

A common assumption is that the return to education is unchanged over time (Krueger and Lindahl, 2000). So the return to schooling is assumed to be constant over time

$$\Delta Y_j = \beta_0' + \beta_{1j} \Delta H_j + \Delta \varepsilon_{jt}' \tag{3}$$

An aspect of the macro-Mincer equation (3) is all schooling can be treated as an investment in a single homogenous construct called human capital. The use of the years of schooling as a single measure of schooling is equivalent to a single measure of human capital. However, the dataset by Barro and Lee (2010) addresses this restrictive assumption. To give a relatively flexible representation of schooling, we consider three levels of schooling, primary, secondary and tertiary education. This it is an improvement to the basic macro-Mincer earnings equation. The following models are thus specified:

$$\Delta Y_{jt} = \beta_0 + \beta_1 \Delta H_{jt}^{\Pr i} + \beta_2 \Delta H_{jt}^{Sec} + \beta_3 \Delta H_{jt}^{Ter} + \beta_4 Y_{j,t-1} + \beta_5 S_{j,t-1} + \beta_6 \Delta teapri_{jt} + \beta_7 \Delta tea\sec_{jt} + \Delta\varepsilon_{jt} \qquad (4)$$

$$\Delta Y_{jt}^{g} = \beta_0 + \beta_1 \Delta H_{jt}^{\Pr i} + \beta_2 \Delta H_{jt}^{Sec} + \beta_3 \Delta H_{jt}^{Ter} + \beta_4 Y_{j,t-1} + \beta_5 S_{j,t-1} + \beta_6 \Delta teapri_{jt} + \beta_7 \Delta tea\sec_{jt} + \beta_8 \Delta pop_{jt} + \Delta\varepsilon_{jt} \qquad (5)$$

where Δ represents the change in the variable from *t-1* to *t*, β_0 is the mean change in the intercepts and $\Delta\varepsilon'_{jt}$ is a composite error that also captures the difference between each country's intercept change and the overall average.

Y_j is the log of real GDP per capita of a country *j*. As with many time series variables that we expect to have an overall trend of exponential growth, we transform the dependent variable by taking the natural logarithm. If we difference log per-capita GDP, we get the growth rate of GDP per capita. This step also removes the long-run growth time trend so that we are dealing with a stationary process. $Y_{j,t}^{g}$ is the value add or the log of real GDP of sector *g* in country *j*. The data on the real GDP $y_{j,t}^{g}$ are computed based on the sectors' shares of real GDP and the real GDP for country *j*, that is, $y_{j,t}^{g} = Share_j^g \times GDP_j$. We compute the value add of main sectors that drive SSA's economic growth. They are agriculture, industry, manufacturing, services, mining and construction. We would have been interested in banking and public administration sectors but such data are poor or unavailable. We also attempt to account for the quality of education across countries by including the pupil-to-teacher ratios at primary and secondary levels, $teapri_{j,t}$ and $tea\sec_{j,t}$ respectively.

The standard macro growth model used in the literature is built on the convergence theory. The convergence hypothesis is that countries that are below their steady-state income levels grow faster and those above the level grow slower. For this reason, the log of initial level GDP per capita, $Y_{j,t-1}$, and the average years of schooling in the population in the initial year, $S_{j,t-1}$, are included. $S_{j,t-1}$ is largely treated as a proxy for steady-state income. Countries with more schooling would be seen to have a higher steady-state income and so would be expected to grow faster $(\beta_5 > 0)$ than countries with low initial stocks of human capital, conditional on GDP in the initial year $Y_{j,t-1}$.

Applying OLS to Equations (3), (4) and (5) yields the first-difference estimator. The first-differences estimator cancels unobservable differences across countries. The equations are estimated using data for a cross-section or pooled sample of countries spanning a 5, 10, or 20 year period. The year length of differencing is crucial to understanding the role of education in growth. A key finding by Krueger and Lindahl (2000) is that time span matters. When differencing over short 5-year periods, the change in schooling has small effect on GDP growth. However, over longer 10 or 20 year periods, increases in average years of schooling have a larger positive and statistically significant effect on growth. This lag effect of education is attributed to the measurement error (noise) inherent in education data. Over short time periods, the change in a country's true average schooling level is very small. This means that there is little variation in the change of schooling over short periods. Consequently, the measurement error inherent in schooling dominates the true change in the schooling variability. However, longer periods capture greater variations in true education levels. Thus, long-period change in true education levels carries more signal and thus dominates the measurement error. The measurement error is largely viewed as a key source of bias in growth regressions. The downward bias means that changes over such short 5-year periods tend to underestimate the effect of education on GDP growth. The measurement error explains why Barro and Sala-i-Martin (1994) do not find a significant effect of short changes in schooling on growth (Krueger and Lindahl, 2000).

The basic macro-Mincer equation (3) does not capture the effects of different levels of education on growth. On the other hand, equation (4) disaggregates education into three different levels. Equation (4) helps us to see if primary education matters more for growth in SSA than post-primary education. That is, the growth of primary education might be expected to have a significant effect on growth. We expect primary education to be more important for SSA's growth than higher education because the general population is relatively less well-educated. Also, SSA economy is still generally driven by agriculture and low-end industry production.

We think the decompostition of the sectoral growths in Equation (5) is useful to see if the changes in the different levels of education affect one sector much more than the other. In other words, the growth impact of different levels of education may differ across sectors. For example, increases in, say, the years of primary education may benefit the growth of one sector, say agriculture, more than that of the industry sector. Then the coefficient for $\Delta H_j^{\text{Primary}}$ should be statistically different from zero for the sector agriculture regression. The results of equation (5) will help to shed some light about whether SSA should industrialize for greater growth (Page, 2010). It should also be highlighted that equation (5) contains an additional variable, Δpop_j which is the changes in the population of each country *j*. Ideally, the dependent variables in equation (5) ought to be the sector *g*'s real GDP per person employed in sector *g*, that is the value-add should be expressed on a per worker basis. Not only does the real GDP per person employed is a better measure of the growth of the sector *g*'s productivity than just real GDP, it would also be comparable to the general GDP per capita model. However, the data on the number of people employed and the shares of labor employed in each sector *g* are not available. The next best approach is to control for population growths for the time period in the study by including the variable in the growth regression (5).

Because we are using OLS estimation method, we need to verify that our data set is in agreement with the basic assumptions underlying OLS regression; otherwise the results of the regressions may be misleading. A basic assumption of OLS is the homogeneity of variance of the residuals. We use the Breusch-Pagan test for heteroskedasticity. The null hypothesis is homogenous or constant variance of residuals. In general, the Breusch-Pagen tests show the *p*-values do not reject constant variance hypothesis, that is, the chi-square values are small, indicating that heteroskedasticity is probably not a problem in the regressions. Hence, tt is likely that residuals or error terms are independent across countries. However, the error terms are likely to be serially correlated within countries. Thus, the standard errors should be clustered. The clustering will adjust for correlations between the error terms over time. However, the consequence of clustering is that in effect there are less independent observations and standard errors are expected to increase. The change in standard errors then may alter the significance of some regression coefficients and hence the result. We report both robust and cluster standard errors.

At this point, we would like to raise two issues in our methodology. First, equation (3) allows the time-invariant return to schooling β_{1j} to vary across countries. If β_{1j} is different for each country, and a constant-coefficient model is applied for estimation, then $(\beta_1 - \beta_{1j})\Delta H_j$ is captured by the error term. This means that if the true effect of education is heterogeneous, the constant-coefficient model would not yield the most efficient weights (Krueger and Lindahl, 2000). They find that education has a heterogeneous effect on economic growth across countries. However, the heterogenous effect only has implication on the convergence literature (Krueger and Lindahl, 2000). But since we mainly focus on the effect of increases in education on economic growth, we will ignore the convergence issue subsequently.

The second issue is the possible endogeneity of education at the macro level. It is likely that when a country experiences faster economic growth, it will invest more in education and thus increases the stock of education human capital in subsequent years. This leads to reverse causality, or 'simultaneous equations' bias. Then, the OLS estimate β_{1j} is then an inconsistent estimate because it confounds these two different effects. This reverse causality problem is acknowledged in recent papers (Krueger and Lindahl 2000; Gyimah-Brempong el at. 2005; Seetanah 2009). The instrumental variable (IV) method is a common approach to overcome the problem of reverse causality. Because the instrument has to be valid (uncorrelated to the growth) and relevant (carries some information about the changes in schooling), IV regression is not always a practical solution and is fraught with difficulties. For example, it is hard to think of an instrument for the changes in education. Parents' education or tests scores seem an unlikely candidate. Perhaps we could consider the changes in the government's expenditure on education as a share of the country's GDP.

4. Data and Descriptive statistics

Formal education is traditionally viewed to contribute to human capital accumulation. This is why empirical growth models have used three main levels of education – primary, secondary and tertiary (higher) – to proxy for human capital accumulation (Gemmell, 1996). The data constructed by Barro and Lee data (1993) seems the most widely used in the literature to estimate the effect of educational improvements or the change in human capital. Almost 60 percent of the variability in observed changes in years of education in the Barro and Lee data is true changes (Krueger and Lindahl, 2000). Their measure of human capital gives information on the stock of human capital and is preferred to alternative measures such as school enrollment ratios and adult literacy rates.

Gyimah-Brempong el at. (2006) explain their choice of educational attainment as a measure. In the empirical growth literature, various measures of education have been used by researches such as enrolment ratios, the proportion of the population that has achieved some level of education and expenditures on education. Education expenditure-to-GDP ratio and enrolment ratios are useful for comparison across countries but are not helpful for the study of the effects of education on economic growth (Gyimah-Brempong el at., 2006). The reason is that both enrolment ratios and expenditures on education are inputs into the production of additional education human capital (Solow 2003), rather than additions to the stock of human capital (Gyimah-Brempong el at., 2006). Enrolment ratios and expenditures are not additions to the human capital itself and do not measure education human capital available for productive purposes. However, the additions to the stock of education human capital are what affect economic growth. Moreover, expenditures and enrolment ratios require the assumption of no cross-country (temporal) differences in efficiency of education production in order to measure accurately cross-country (time series) differences in investments in education. Hence, education attainment is a better measure of education human capital. Gyimah-Brempong el at. (2006) measure *higher*, *secondary* and *primary* as the average number of years of higher, secondary and primary education completed by the adult population (25 years or older) in a country in a period.

The data on the average years of schooling for the population age 15 and above is based on Barro and Lee data (2010). The principal source of data used in this study is the websites of the World dataBank and the UNESCO Institute for Statistics. The sample analyzed in this study consists of 33 countries from Sub-Saharan African region. Other countries have been excluded from the sample solely on the basis of data unavailability on the average years of schooling in Barro and Lee data (2010). The complete list of countries in the sample is presented in Appendix 1.

Table 1 presents the summary statistics on the dependent and independent variables used in the model. The time period spans between 1960 and 2010. The dependent variable is the change in aggregate real output of each country which is measured by the log of real GDP per capita in constant 2000 US dollars. The data is taken from the World databank website. GDP per capita is used because it captures labor force participation decisions and because it is also the emphasis of previous literature. Average per-capita income increases by 0.7% every five years. The agriculture sector shows the least growth in total income of 1.6%. The industry and mining sectors enjoy the fastest increase in income. All the growth rates have high variance, reflecting that within the SSA region, not all countries enjoy the same rate of economic development.

On average, the services sector has the largest share of GDP of 42.6%, followed by agriculture of 31.8% and industry of 25.8%. Manufacturing, a subset of the industry, constitute about 11% of GDP. There is no data on the shares of GDP for the mining and construction sectors. We also make an important observation about the trends in the shares. We find that while the share of GDP for agriculture sector shows a decreasing trend, the shares of industry, manufacturing and services enjoy increasing trends. For example, the share for agriculture sector decreases relatively steeply by about 0.36% for five-year changes. The share for services sector enjoys a relatively large increase by about 0.29% every five-year period. The trends suggest the declining importance of the agriculture sector for economic growth and the growing contribution of other industry sectors and services to GDP growth in SSA.

The quality of education is measured by the pupil-teacher ratios at primary and secondary levels. Both variables are observed almost annually and taken from the World dataBank and UNESCO websites. We note that the average pupil-to-teacher ratios at primary and secondary levels are 44 and 24 respectively. The ratios show that the average class sizes at both levels are quite large by international standard and are less than ideal for condusive learning. Between 1960 and 2010, students per teacher at primary level declines while the ratio increases at secondary level. The ratios have high standard deviation, suggesting that the quality of education in terms of the average primary and secondary student in a school gaining knowledge in any year of schooling is likely to differ across the countries. The range of the primary pupil-teacher ratio is higher than that of the secondary pupil-teacher ratio. The number of primary pupils per teacher ranges from 20 to 324. The number of secondary pupils per teacher varies between 8 and 80. There is no data on the pupil-teacher ratio at tertiary level. Data on other possible ideal measures of educational quality (as explained in Section 2.11), such as family inputs, repetition rates, average teacher salaries as a share of a country's GDP, dropout rates, real public spending per pupil, international student attainment test scores (Hanushek and Wobmann, 2007) are unfortunately poor, if not unavailable, for the countries and the time period under study.

Unlike Krueger and Lindahl (2000) who look at the population aged 25 and over, we focus our attention on population aged 15 and over. We agree with Gemmell (1996) that the latter population is considered to be carry more valuable information for a study made on developing countries because the average poor person is likely to join the labor force at an early age to support his living when his family is unable to. We follow Krueger and Lindahl (2000) and divide the change in average schooling by the number of years in the time span to make it easy to compare coefficients across columns. The education data gives the average years of schooling for the population aged 15 and above at primary, secondary and tertiary levels. The three variables are available on five year intervals between 1960 and 2010. The average years of schooling at primary, secondary and tertiary levels are 2.51, 0.79 and 0.04 respectively. The low mean years of secondary and tertiary schooling indicate that the population in SSA is relatively less highly-educated than those in other regions (Barro and Lee, 2010). The average year of total schooling variable has high standard deviation and ranges between 1 year and 10 years. The average years of primary schooling also has high variance and ranges between 1 year and

6 years. The average years of secondary and tertiary schooling show less variance. The average year of education increases by 0.8 year. Also, the years of schooling at primary, secondary and tertiary levels also show positive growth. However, the growth in tertiary years of schooling is very little at about 0.01 year. The growth in the average years of schooling is not very much different whether the differences are taken over 5, 10 or 20 years.

Prior to running the growth regressions, we plot the relationships between the log differences in income per capita and the log differences in the average years of schooling. These are shown for the period 1960 to 2010 in Figure 1. We notice a mild positive relationship between the log difference income per capita and the log difference average years of schooling for a 5-year change. The positive relationship is stronger when the log differences in both variables for 10-year change. The positive relationship between the log change in income per capita and the log change in the average schooling is most noticeable for 20-year difference.

5. Empirical Results

The OLS coefficient estimates of the equations are presented in Tables 2 to 8. Both the robust and cluster standard errors are reported. In general, the changes in schooling almost always enter with a positive coefficient and at times enter significantly.

Table 3 shows the regression result that supports the result in Krueger and Lindahl (2000). The change in schooling appears to have little and insignificant effect on GDP growth when the growth equation is estimated based on 5-year differences. However, the effect of an increase in the average years of total schooling becomes positive and statistically significant for differences of 10-year at 10% level and 20-year at strongly 1% level (based on robust standard errors). That is, we observe that the magnitude and the significance of the coefficient estimates increase with the length of difference in the years. Our result is consistent with that in Krueger and Lindahl (2000) which finds that time span matters for the change in education to effect on the GDP growth. For 5-year differencing, only 0.8% of the variation in GDP growth per capita is due to the change in the schooling. However, for 20-year differences, 9.1% of the change in GDP growth is attributed to increases in the schooling. The high coefficient on schooling may indicate that increases in schooling produce large externalities (consistent with Lucas, 1988) or is caused by greater growth (the endogeneity problem of simultaneous causality) which is likely to occur over long time periods.

Table 4 present the estimation results of equation (4). Only the increases in average year of primary education have a positive and strongly statistically significant effect on GDP growth for 20-year changes. 9.4% of the variation in the log GDP changes can be explained by the changes in the schooling at primary level. Although the coefficients of the changes in secondary and tertiary schooling are positive, we do not find the coefficients significant for all three time period changes. This seems to suggest that the increases in higher education have not helped SSA's economic growth. The estimates show a similar result to Gemmell's (1996) who predict that the growth of primary education may have a significant effect on growth in low-income developing countries, but no effect in high-income developed countries where almost everyone has primary education and where secondary and tertiary drive the bulk of human capital accumulation. On another note, the coefficient of the initial average years of schooling $S_{j,t-1}$ is positive and significant in the long run of 20-year changes. This seems consistent with the convergence theory as explained in Section 3. That is, countries with more schooling are treated to have a higher steady-state income and hence tend to grow faster than those with less schooling. Another interpretation of the positive estimate of $S_{j,t-1}$ is that schooling could alter the steady-state growth rate by enabling workers to adopt and develop new technologies. Yet another interpretation is that the 'catch-up' effect is higher among countries with below average income but attain higher average education (Krueger and Lindahl, 2000).

Tables 5, 6, 7, 8 and 9 show the estimation result of equation (5) for the sectors agriculture, industry, manufacturing, services and mining respectively. The specifications allow us to see whether growth of primary education has a significant effect on the growth of value-add in agriculture sector where skilled labor is not a pre-requisite, but has little impact in industry sector where skilled labor is in demand.

The regression result in Table 5 indicates that primary education has the largest positive and significant effect on the growth of GDP in the agriculture sector in the long run of 20-year period. The next result is strange: increases in secondary schooling have a large positive effect on the growth of agriculture's value-add over the short period of 5-year differences. Given that this is statistically significant at 10% level, we infer that more secondary schooling account for the growth of agriculture development in the short-run.

The industry sector consists of manufacturing, mining and construction sectors. Table 6 shows that education does not have much effect on the growth of industry's GDP over the short period of 5-year and the long period of 20-year differences. However, over the medium period of 10-year, changes in tertiary education has a large positive effect which is significant at 10% level. The effect is too large and is quite suspicious though.

Manufacturing is a subset of industry sector. In the case of the growth of manufacturing, the effect of education is looks optimistic in Table 7. For both the short 5-year and medium 10-year periods, increases in secondary schooling have a fairly large effect on the growth of GDP of the manufacturing sector and the effect is significant at 10% level. Changes in the primary and tertiary education do not seem to matter. This shows that the manufacturing industry requires workers who are more highly educated and the growth of the manufacturing sector depends on the increases in the average year of secondary schooling. Given the increasing trend in the share of the manufacturing sector, the result seems to support Page (2010) that the low rate of increase in higher education in SSA and Africa would derail Africa's industrialization progress and potential economic growth.

Education has also shown to matter for the growth of the GDP of the service sector in Table 8, at least over the short and medium 5-year and 10-year time periods. The changes in tertiary education have a positive and strongly statistically significant effect on service's GDP growth over short 5-year periods. A good explanation is that the service sector produces more sophisticated products that require high-skilled labor. The service sector includes wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services.[2] Given that the service sector accounts for the largest share of GDP of 42.6% on average, the lack of skilled labor is likely to pose serious threat to the growth of the service sector and the general economic growth for SSA. Finally, education does not seem to have any effect on the growth of the mining sector in SSA. The weak effect of changes in education may be due to the relatively small samples.

Notice that we exclude the coefficients for the changes in pupil-to-teacher ratios to keep the sample size larger and also because they always enter insignificantly. The inclusion of the ratio changes in the regressions does not affect the overall significance of the result. To test the robustness of our results for the effect of changes in schooling on growth, we include the pupil-to-teacher ratios. The results in Table 10 yield the same finding as that of Table (2): changes in primary education have a positive and significant effect on growth for longer changes in time periods.

Finally in Tables 11 and 12, we include *year* dummies variables in the regressions of the equations (3) and (4) (Tables 3 and 4) so as to account for any global shock effects such as those due to spikes in oil prices during world oil crisis. Tables 10 and 11 present the estimation results of the coefficients of our interests and exclude the results of each year. After taking into consideration of the global effects, Table 10 finds that the effect of changes in education on growth becomes significant at 5% level for 5-year differences. Also, the coefficient of ΔH (0089) has a magnitude twice greater than the estimate coefficient of ΔH in Table 3 (0.040). The significance of the effect of more education also increases (at 5% level) for 10-year changes. However, there is not much change in terms of both magnitude and significance of ΔH over 20-year time period. Table 12 also shows that the significance of the effect of more schooling at primary, secondary and tertiary level does not change with the inclusion of *year* dummy variables. The effect of more primary education is still shown to be the only significant effect on growth after 20 years.

[2] World dataBank website

6. Conclusion

This paper uses panel data from a sample of Sub Saharan countries for the 1960-2010 period and a first-difference estimated to investigate the effect of changes in primary, secondary and tertiary education on the growth rate of per capita income as well as the growths of various sectors in these SSA countries. We estimate based on a modified macro-Mincer equation which allows us to disaggregate education into different levels so as to establish the true effects of different levels of education on economic growth. We find that changes in education have a positive and statistically significant effect on the growth rate of per capita income, especially over longer differences of 10-year and 20-year. Our result is similar with the finding by Krueger and Lindahl (2000) that the change in education is positively related with economic growth. Furthermore, it is changes in primary education, rather than changes of secondary and tertiary education, that have a positive and significant effect on the general growth over 20-year changes in developing SSA countries. Our finding supports Gyimah-Brempong (2005) and Gemmell (1996) that increases in primary education is indeed the important catalyst for the growth in Sub Saharan Africa. This implies that the focus to provide universal primary education to increase the growth of income in African countries may be in the right track. The result is also robust to the inclusion of pupil-to-teacher ratios at primary and secondary levels in the regressions. We note that our estimate of the long-run growth impact of changes in education found in cross-country models may be over-estimated due to reverse causality or omitted variable bias problems. Furthermore, countries with increased education may pursue other economic growth policies at the same time, leading to a different potential omitted-variable bias in cross-country regressions. Unfortunately, the IV approach may not be a practical option to ensure exogeneity in the education data. Krueger and Lindahl (2000) propose either using data based on natural experiment or that the growth effect of education examine across regions within countries. We suggest that perhaps future research may look into controlling for the change in government’s expenditure on education as a share of the country’s GDP.

This paper also sheds light about education-industrialization relationship for Africa. Different sectors have shown to reap different benefits from the same increases in education. We find that the growth impact of changes in, say, primary education has a significant effect only on the growth of value-add of the agriculture sector over 20-year changes. Increases in secondary education are positively and significantly related to the growths of value-add of sectors agriculture, mining and especially manufacturing. Changes in tertiary education have a positive and strongly significant effect on the service sector. We find that the industry sector is not very much affected by the change in education, although its subset, manufacturing, does. The policy implication from our result is that SSA should not neglect the provision of post-primary and higher education at the expense of universal primary education. This is especially crucial given that steady increasing trends in the shares of industry, manufacturing and service sectors as a percentage of the overall GDP. The governments must ensure that more people are provided quality higher education if SSA wants to develop its more sophisticated sectors such as industry and services and achieve greater economic growth.

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Appendix 1: Sub Saharan African countries in the sample

Benin	Gambia, The	Mozambique	Swaziland
Botswana	Ghana	Namibia	Tanzania
Burundi	Kenya	Niger	Togo
Cameroon	Lesotho	Nigeria	Uganda
Central African Republic	Liberia	Rwanda	Zambia
Congo, Dem. Rep.	Malawi	Senegal	Zimbabwe
Congo, Rep.	Mali	Sierra Leone	
Cote d'Ivoire	Mauritania	South Africa	
Gabon	Mauritius	Sudan	

Table 1: Table of Variables

Variable	Description
ΔY_t	The growth rate of real GDP per capita / Change in real GDP per capita, where *t* = 5, 10 or 20 year differences
ΔY_t^g	The growth rate of real GDP or value-add of sector *g*, where *t* = 5, 10 or 20 year differences
$Share^g$	Share of the value-add of sector g as a percentage of GDP
$\Delta Share_t^g$	Changes in $Share^g$, where *t* = 5, 10 or 20 year differences
H	Average years of total schooling for population aged 15 and above
$H^{\Pr i}$	Average years of primary schooling for population aged 15 and above
H^{Sec}	Average years of secondary schooling for population aged 15 and above
H^{Ter}	Average years of tertiary schooling for population aged 15 and above
ΔH_t	Changes in H over *t* years, where *t* = 5, 10 or 20 year differences
$\Delta H_t^{\Pr i}$	Changes in $H^{\Pr i}$ over *t* years, where *t* = 5, 10 or 20 year differences
ΔH_t^{Sec}	Changes in H^{Sec} over *t* years, where *t* = 5, 10 or 20 year differences
ΔH_t^{Ter}	Changes in H^{Ter} over *t* years, where *t* = 5, 10 or 20 year differences
$teapri$	Pupil-teacher ratio in primary school
$tea\sec$	Pupil-teacher ratio in secondary school
$\Delta teapri$	Changes in $teapri$ over 5 years
$\Delta tea\sec$	Changes in $tea\sec$ over 5 years
Δpop	Changes in the total population

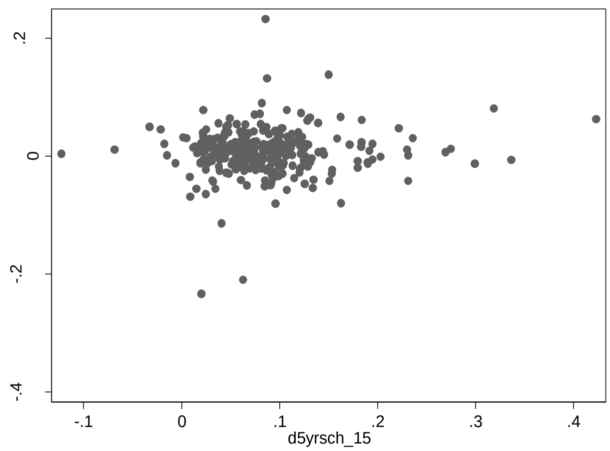
Table 2: Summary Statistics

Variable	Obs	Mean	Std. Dev	Min	Max
ΔY_5	1384	.007	.040	-.374	.232
ΔY_{10}	1219	.006	.031	-.222	.115
ΔY_{20}	889	.002	.025	-.126	.094
$\Delta Y_5^{Agirculture}$	1219	.017	.050	-.345	.327
$\Delta Y_5^{Industry}$	1205	.040	.079	-.632	.609
$\Delta Y_5^{Manufacturing}$	1068	.037	.070	-.298	.556
$\Delta Y_5^{Service}$	1247	.039	.069	-.574	.590
ΔY_5^{Mining}	653	.053	.151	-.495	.735
$Share^{Agriculture}$	1427	31.808	16.806	1.833	94.846
$Share^{Industry}$	1411	25.830	12.972	1.882	80.215
$Share^{Manufacturing}$	1272	11.264	6.926	0.802	45.167
$Share^{Service}$	1413	42.568	10.849	4.141	72.884
$\Delta Share_5^{Agricultre}$	1256	-.363	1.423	-9.256	7.675
$\Delta Share_5^{Industry}$	1237	.151	1.264	-4.883	5.979
$\Delta Share_5^{Manufacturing}$	1095	.049	.676	-4.968	4.129
$\Delta Share_5^{Service}$	1242	.204	1.40	-4.701	6.861
H	363	3.344	2.114	.191	9.563
$H^{Primary}$	363	2.515	1.476	.175	6.281
$H^{Secondary}$	363	.786	.748	.014	3.171
$H^{Tertiary}$	363	.043	.052	0	.444
ΔH_5	330	.080	.059	-.122	.423
ΔH_5^{Pri}	330	.054	.037	-.121	.228
ΔH_5^{Sec}	330	.025	.028	-.043	.184

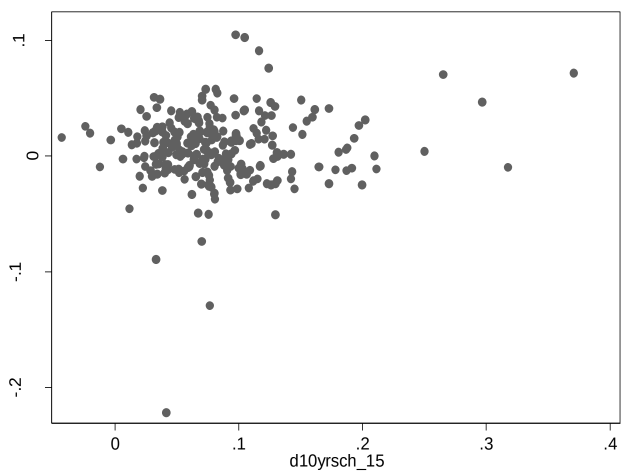
Variable	Obs	Mean	Std. Dev	Min	Max
ΔH_5^{Ter}	330	.001	.004	-.023	.034
ΔH_{10}	297	.083	.053	-.043	.371
$\Delta H_{10}^{\text{Pri}}$	297	.056	.033	-.026	.182
ΔH_{10}^{Sec}	297	.026	.026	-.032	.181
ΔH_{10}^{Ter}	297	.001	.003	-.011	.030
ΔH_{20}	231	.086	.046	-.009	.284
$\Delta H_{20}^{\text{Pri}}$	231	.058	.028	-.007	.157
ΔH_{20}^{Sec}	231	.027	.022	-.013	.127
ΔH_{20}^{Ter}	231	.002	.002	-.005	.019
$teapri$	1116	43.663	15.174	19.268	324
$tea\sec$	852	23.579	7.692	7.302	80.052
$\Delta teapri$	868	-.066	2.45	-58.44	6.187
$\Delta tea\sec$	557	.067	1.088	-5.492	5.279

Figure 1: Log difference in income per capita versus log difference in years of schooling

a) 5-year changes



b) 10-year changes



c) 20-year changes

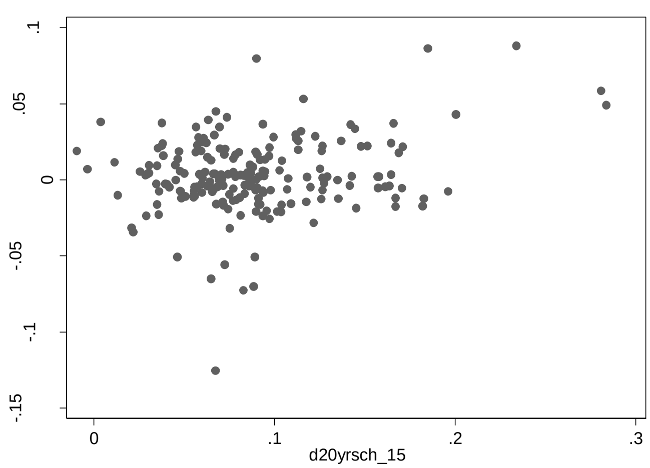


Table 3: The Effect of Schooling on Growth

Dependent Variable: Change in Log GDP per Capita

	5-year changes	10-year changes	20-year changes
	(1)	(2)	(3)
ΔH	.040	.062	.145
	(.039)	(.037)*	(.040)***
	[.045]	[.061]	[.095]
Y_{t-1}	-.001	-.002	-.006
	(.003)	(.003)	(.002)
	[.003]	[.003]	[.003]
S_{t-1}	.001	.001	.003
	(.001)	(.001)	(.001)
	[.001]	[.001]	[.002]
R^2	.008	.017	.091
N	300	267	201

( ) robust standard errors [ ] cluster standard errors

*significant at 10% level **significant at 5% level ***significant at 1% level

Table 4: The Effect of Primary, Secondary and Tertiary Schooling on Growth

Dependent Variable: Change in Log GDP per Capita

	5-year changes	10-year changes	20-year changes
	(1)	(2)	(3)
$\Delta H^{Primary}$	.000	.041	.163
	(.076)	(.074)	(.082)**
	[.073]	[.106]	[.135]
$\Delta H^{Secondary}$	.090	.090	.143
	(.104)	(.098)	(.111)
	[.077]	[.102]	[.161]
$\Delta H^{Tertiary}$	.136	.074	-.426
	(.631)	(.635)	(.793)
	[.371]	[.455]	[1.45]
Y_{t-1}	-.001	-.003	-.006
	(.003)	(.003)	(.003)
	[.003]	[.003]	[.003]
S_{t-1}	.001	.001	.003
	(.001)	(.001)	(.001)**
	[.001]	[.001]	[.001]*
R^2	.008	.018	.094
N	300	267	201

Table 5: The Effect of Primary, Secondary and Tertiary Schooling on Sectoral Growth

Dependent Variable: Change in Log GDP of Agriculture sector

	5-year changes	10-year changes	20-year changes
	(1)	(2)	(3)
$\Delta H^{Primary}$	-.077	.019	.128
	(.094)	(.080)	(.078)*
	[.103]	[.100]	[.125]
$\Delta H^{Secondary}$	.204	.126	.013
	(.122)*	(.106)	(.102)
	[.107]	[.139]	[.167]
$\Delta H^{Tertiary}$	-.207	.526	-1.013
	(1.954)	(1.130)	(.890)
	[.645]	[1.087]	[1.040]
Y_{t-1}	-.005	-.007	-.005
	(.006)	(.003)	(.003)
	[.003]	[.004]	[.004]
S_{t-1}	-.002	-.002	-.002
	(.002)	(.001)	(.001)
	[.002]	[.002]	[.002]
Δpop	.000	.000	.000
	(.000)	(.000)	(.000)*
	[.000]*	[.000]	[.000]
R^2	.039	.069	.148
N	261	229	166

Table 6: The Effect of Primary, Secondary and Tertiary Schooling on Sectoral Growth

Dependent Variable: Change in Log GDP of Industry sector

	5-year changes	10-year changes	20-year changes
	(1)	(2)	(3)
$\Delta H^{Primary}$	-.021	-.031	.152
	(.159)	(.132)	(.173)
	[.124]	[.157]	[.241]
$\Delta H^{Secondary}$	.138	.128	.191
	(.179)	(.192)	(.249)
	[.170]	.226	[.344]
$\Delta H^{Tertiary}$	1.623	3.015	.747
	(2.919)	(2.144)	(3.107)
	[1.647]	[1.652]*	[3.615]
Y_{t-1}	-.004	-.010	-.015
	(.009)	(.005)	(.006)
	[.006]	[.007]	[.007]
S_{t-1}	-.003	-.001	.002
	(.003)	(.002)	(.003)
	[.003]	[.003]	[.003]
Δpop	.000	.000	.000
	(.000)	(.000)	(.000)
	[.000]	[.000]	[.000]
R^2	.017	.039	.065
N	257	225	162

Table 7: The Effect of Primary, Secondary and Tertiary Schooling on Sectoral Growth

Dependent Variable: Change in Log GDP of Manufacturing sector

	5-year changes (1)	10-year changes (2)	20-year changes (3)
$\Delta H^{Primary}$	-.313	-.212	.062
	(.215)	(.151)	(.166)
	[.214]	[.179]	[.252]
$\Delta H^{Secondary}$	.355	.316	.150
	(.205)*	(.185)*	(.219)
	[.192]*	[.211]	[.289]
$\Delta H^{Tertiary}$	1.730	2.871	.386
	(3.406)	(2.801)	(1.745)
	[2.400]	[2.539]	[2.462]
Y_{t-1}	-.005	-.007	-.008
	(.010)	(.007)	(.006)
	[.010]	[.009]	[.008]
S_{t-1}	-.004	-.002	.0004
	(.003)	(.003)	(.003)
	[.003]	[.003]	[.004]
Δpop	.000	.000	.000
	(.000)	(.000)	(.000)
	[.000]	[.000]	[.000]
R^2	.043	.055	.038
N	227	196	136

Table 8: The Effect of Primary, Secondary and Tertiary Schooling on Sectoral Growth

Dependent Variable: Change in Log GDP of Service sector

	5-year changes (1)	10-year changes (2)	20-year changes (3)
$\Delta H^{Primary}$	.003	.015	.147
	(.117)	(.102)	(.125)
	[.114]	[.150]	[.190]
$\Delta H^{Secondary}$	.073	.152	.230
	(.156)	(.165)	(.196)
	[.170]	[.210]	[.299]
$\Delta H^{Tertiary}$	2.090	2.420	.352
	(2.347)***	(1.307)*	(2.804)
	[.623]	[.682]***	[3.367]
Y_{t-1}	-.004	-.009	-.011
	(.008)	(.004)	(.005)
	[.004]	[.005]	[.005]
S_{t-1}	.0004	.002	.004
	(.003)	(.002)	(.002)**
	[.002]	[.002]	[.002]*
Δpop	.000	.000	.000
	(.000)	(.000)	(.000)
	[.000]	[.000]	[.000]
R^2	.015	.040	.062

N	265	233	169

Table 9: The Effect of Primary, Secondary and Tertiary Schooling on Sectoral Growth

Dependent Variable: Change in Log GDP of Mining sector

	5-year changes	10-year changes	20-year changes
	(1)	(2)	(3)
$\Delta H^{Primary}$	.538	.536	.770
	(.399)	(.420)	(.432)*
	[.445]	[.574]	[.649]
$\Delta H^{Secondary}$	-.772	-.826	-.509
	(.550)	(.509)	(.533)
	[.550]*	[.566]	[.794]
$\Delta H^{Tertiary}$	1.110	4.451	6.825
	(4.461)	(5.372)	(8.842)
	[5.522]	[7.992]	[11.035]
Y_{t-1}	-.009	-.009	-.011
	(.017)	(.014)	(.020)
	[.015]	[.016]	[.023]
S_{t-1}	-.007	-.008	-.012
	.010	(.009)	(.011)
	.009	[.010]	[.014]
Δpop	.000	.000	.000
	(.000)	(.000)	(.000)
	[.000]	[.000]	[.000]
R^2	.038	.063	.164
N	128	104	58

Table 10: The Effect of Schooling on Growth

Dependent Variable: Change in Log GDP per Capita

	5-year changes	10-year changes	20-year changes
	(1)	(2)	(3)
ΔH	.053	.089	.192
	(.037)	(.041)**	(.065)***
	[.049]	[.073]	[.118]
Y_{t-1}	.002	-.000	-.008
	(.004)	(.004)	(.004)
	[.004]	[.004]	[.006]
S_{t-1}	.001	.001	.003
	(.001)	(.001)	(.001)
	[.001]	[.001]	[.002]
$\Delta teapri$	.000	-.000	-.000
	(.000)	(.000)	(.000)
	[.001]	[.000]	[.001]
$\Delta tea\sec$	.003	.001	.001
	(.002)	(.002)	(.005)
	[.001]*	[.002]	[.005]
R^2	0.046	0.055	0.182
N	198	166	118

.

Table 11: The Effect of Schooling on Growth (with *year* dummies included)

Dependent Variable: Change in Log GDP per Capita

	5-year changes	10-year changes	20-year changes
	(1)	(2)	(3)
ΔH	.089	.104	.164
	(.040)**	(.044)**	(.053)***
	[.055]	[.070]	[.101]
Y_{t-1}	-.002	-.003	-.007
	(.004)	(.003)	(.002)
	[.003]	[.003]	[.004]
S_{t-1}	.002	.002	.004
	(.002)	(.002)*	(.001)***
	[.002]	[.002]	[.002]*
R^2	.138	.0167	.213
N	300	267	201

Table 12: The Effect of Primary, Secondary and Tertiary Schooling on Growth (with *year* dummies)

Dependent Variable: Change in Log GDP per Capita

	5-year changes	10-year changes	20-year changes
	(1)	(2)	(3)
$\Delta H^{Primary}$	.062	.085	.181
	(.073)	(.071)	(.082)**
	[.078]	[.110]	[.135]
$\Delta H^{Secondary}$	.112	.116	.143
	(.107)	(.113)	(.126)
	[.119]	[.143]	[.189]
$\Delta H^{Tertiary}$	.302	.340	.077
	(1.131)	(.921)	(1.148)
	[.352]	[.559]	[1.58]
Y_{t-1}	-.002	-.003	-.007
	(.004)	(.003)	(.003)
	[.003]	[.003]	[.003]
S_{t-1}	.002	.003	.004
	(.002)	(.001)	(.001)**
	[.002]	[.002]	[.002]
R^2	.139	.168	.213
N	300	267	201