SOURCES OF GROWTH IN SUB-SAHARAN-AFRICAN COUNTRIES: A GROWTH ACCOUNTING ANALYSIS OVER 1980-2011 TIME PERIOD

By

BEZE, Eyayaw Teka

THESIS

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KDI School of Public Policy and Management
in partial fulfillment of the requirements
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Committee in charge:

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ABSTRACT

SOURCES OF GROWTH IN SUB-SAHARAN-AFRICAN COUNTRIES: A GROWTH ACCOUNTING ANALYSIS OVER 1980-2011 TIME PERIOD

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Beze Eyayaw Teka

This paper examines the sources of growth in Sub-Saharan African countries, using the growth accounting framework and estimate aggregate production function by analyzing Penn World Tables (version 8.1) data of over 30 years. In addition, it compares the sources of growth for subgroups and sub-periods. The overall performance of the SSA region was not impressive during 1980-2011 period, output grew by 3.7 percent while per capita GDP grew by 0.8, reflecting the region being victim of prolonged conflicts and civil wars. Capital deepening has contributed 0.2 percent points to the growth of per worker output. Factor accumulation accounted 3.1 percentage points for output growth while TFP accounted 0.6 percent for output growth over the entire period. As the results show it turns out that average real GDP growth in the region during 1980-2011 was mainly driven by factor accumulation with modest role for TFP. Unlike in the previous studies, TFP constitutes a bigger portion of per capita output growth in the region, it accounts 75 percent (0.6 out of 0.8 percentage points) for the per capita output growth although human capital effect is the whole reason for the growth of TFP.

Therefore, the old image of TFP being nil in the region is not correct anymore. In addition, TFP improvements have been changing differently across time periods and subgroups. It has kept increasing overtime. On average the growth of TFP was negative in the first decade, 1980-1990, (i.e., -0.1 percent), but it grew positively thereafter in the rest decades. Without a separate account of TFP and human capital, the growth of TFP was 0.4 percent in 1991-2001 and 1.4 percent in 2002-2011 period. At the subgroup level as well TFP has shown a positive trend overtime. On average, low income countries have experienced lesser TFP growth (0.4 percent) than all the other subgroups, and high income group (Equatorial Guinea) took the lead with 3.8 percentage TFP growth during the entire period.

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Indeed, God is the first!

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1. INTRODUCTION

1.1.Background

Growth accounting was started back in 1957 by Robert Solow who is regarded as the seminal contributor to growth literature. It has become a growing subject in economics since then. However, the subject has got much attention recently after researchers such as Krugman (1994) and Young (1995) brought an amazing assertion that the East Asian growth miracle was driven primarily by factor accumulation rather than total factor productivity (TFP). Following these findings debate has escalated that whether the East Asian miracle was driven primarily by factor accumulation (capital and labor) or TFP. The body of literature in growth accounting has been so big, especially in developed countries (because of earlier availability of data) and cross-country comparison has long been conducted widely[1]. At the regional level of SSA, however there are a few studies of growth accounting and but considerable amount of studies at country level.

The bulk of the literature in the region, for 1960-2004 time period, indicated that factor accumulation is the primary source of growth in sub-Saharan Africa, with insignificant contribution from TFP growth. This paper examines the sources of growth in sub-Saharan African countries, using the growth accounting framework by analyzing Penn World Tables (version 8.1) data over 30 years of time coverage. In addition, it compares the sources of growth for subgroups and sub-periods.

[1] For instance Aghion and Howitt (2007), Bosworth et.al(1995), Bosworth and Collins (2003), Tahari et.al (2004)

Bosworth and Collins (2003) defined growth accounts as a means of decomposing observed output growth into the contributions of changes in factor accumulation and residual, total factor productivity (TFP), *"which measures a combination of changes in efficiency in the use of inputs and changes in technology*". Charles Hulten also describes the growth accounting as "a simple and internally consistent intellectual framework for organizing data. . . . For all its flaws, real and imagined, many researchers have used it to gain valuable insights into the process of economic growth."

Despite its extensive use within the industrial countries, growth accounting has received a lot of criticism for not going beyond mere distinguishing of the contribution of increased capital per worker from that of improvements in total factor productivity and more. But, let alone the nature of the growth accounting approach, even scholars have divergent views on capital accumulation, some claiming that it is an unimportant part of the growth process and others that it is the fundamental determinant of growth (Bosworth and Collins, 2003).

Criticism of growth accounting revolves in the areas of measurement, difficulty imposed by capital measurement and the way TFP measured—as residual, underlying assumptions of the production process and people's confusion of "accounting and casual relationship. More precisely, attributing residuals to only technical change, the fact that growth decomposition results could be sensitive to the assumption of production function and to the proxies chosen to measure output and inputs, the problems of measuring capital, and the difference between

"accounting and casual relationship"[2] are the issues that put growth accounting in a serious criticism for long.

Above all the fact that TFP measured as a residual, TFP measuring combination of changes in efficiency in the use of inputs and changes in technology, is diabolical to the growth accounting analysis bringing so much of the criticism. Scholars point that residuals cannot merely be attributed to these changes, rather these changes in efficiency and technology reflect myriad determinants, in addition to technological innovation. These determinants include other forces that influence growth but that the measured increases in factor accumulation do not account for, on top of technology innovation. Therefore, residuals should not be taken as an indicator of technical change, since residuals could also include the impact of sustained political turmoil, external shocks, changes in government policies, institutional changes, and measurement error (Bosworth and Collins, 2003).

To talk a little about the current facts of SSA region, according to the World Bank[3] growth in SSA was 4.5 percent in 2014 and expected to slow to 4.1 percent in 2015, owing to decline in prices of oil and other commodities and Ebola crisis. The region's GDP is highly sensitive to oil price fluctuations due to the fact that SSA's oil exporters[4] account for nearly half of the region's GDP. At country level, prospects in Nigeria and Angola have deteriorated because of the sharp drop in the price of oil, and in South Africa due to electricity interruptions. But due to infrastructure investment and agriculture expansion, most low income countries' growth

[2] See Aghion and Howitt (2007) for complete understanding of the difference between accounting and causal relationships when interpreting the results of growth accounting.
[3] Global Economic Prospects Sub-Saharan-Africa Analysis, WB, 2015
[4] Main oil exporters in the region include Angola, Cameroon, Congo (Republic), Chad, Equatorial Guinea, Gabon, and Nigeria. Nigeria and Angola are the largest amongst; they are also the region's first and third largest economies.

experience will remain strong, and higher public investment and the recovery of tourism (following the recede of Ebola) will help lower-middle- and upper-middle-income countries enjoy increased growth as well. Continued expansion of nonoil sectors, particularly services, is expected to lift growth in 2016 and beyond, in the region as a whole.

1.2. Objective of the Study

The objectives of this paper are:

- to estimate aggregate production function both at the aggregate level (SSA wholly) and subgroup levels of low income, lower middle income, upper middle income and higher income countries. and
- to compute growth accounting of SSA countries, at regional (aggregate) level, country level and subgroups, in the time period of 1980-2011.

1.3. Limitation 0f the Study

The unavailability of human capital data for some countries precludes us from conducting the growth accounting exercise with complete split between the contribution of human capital accumulation and TFP. The problem, though not satisfactorily (because the analysis using 32 countries with human capital data might not fully represent the whole region and we cannot infer findings from such analysis to tell about the region), partially has been ameliorated with an attempt of doing the growth accounting exercise in a framework which puts TFP and human capital separately. The problem of this analysis is that, however, the sample size is limited, 32 out of 43 countries only sampled. In order for better understanding of the growth decomposition of the region, human capital data series should be produced in each country in a constant manner.

1.4. Significance of the Study

- The answers for the questions would come up with the explicit sources of growth and how the aggregate production function looks like in the region so that clues as to where resources and money (even aid) should be directed will be seen. In addition, the answers will aid government policies makers to go for reallocation of resources to more productive inputs, if necessary.
- The literature in the subject of study in the region is limited so my paper would be a humble addition.

4. LITERATURE REVIEW

4.1. Economic Growth: Definition

According to World Bank economic growth can be defined as a quantitative change or expansion in a country's economy (output or income). We say an economy exhibits growth, for example, if there is a change in goods and services produced by that economy, over a specified period of time. (Although it might seem just positive change for the general public, economic growth can be both positive and negative changes in the level of country's economy). Mostly, growth of real or inflation-adjusted per capita GDP or GNP is used as a measure of economic growth during one year. In this paper real GDP per capita is used as a measure of economic growth, and economic growth should not be confused with economic development (a concept which is beyond this paper). The reason why we usually use real (per capita) GDP is because of our definition of economic growth as the expansion of output (goods and services). In such a case real GDP or preferably real GDP per capital which takes into account population of a country is a satisfactory measure.

Having economic growth defined that way one might ask how has economic growth been achieved historically and what have been/are the determinants of economic growth of a certain economy in general? Generally speaking, economic growth can be brought by "extensive production" which means by using more endowments (resources) such as labor, physical or human capital or, "intensive production" by using the same amount of resources more efficiently and effectively.[5] As I talk in the methodology part of this paper, the total output of an economy

[5] http://www.worldbank.org/depweb/english/beyond/global/glossary.html

is a function of its resource endowments (labor, physical capital, human capital, etc.) and the technology with which these endowments are combined to produce a flow of goods and services (GDP). The famous Cobb-Douglas production function shows that relationship nicely, and it is the most chosen one in growth accounting exercise for its mathematical convenience and simplicity. So with that structure of production function in mind, output can be expanded (i.e., growth can be achieved) by factor accumulation (by accumulating more capital over time, for instance) and/or technological progress (by employing new better technique of production).

While accumulating more capital can be directly translated into higher per capita growth--at least in the short run--, achieving economic growth by using more labor may not necessarily result in per capita income growth as high growth of labor (or population) might swallow out the growth of output[6]. But when economic growth is achieved through growth in productivity, it results in higher per capita income and improvement in standard of living[7].

Hiring more labor or accumulating more capital, or more productive use of all resources, however, are "proximate determinants" of economic growth according to Rodrik (2003). He argues that the correlates of growth go beyond economic variables (such as labor and capital) to "deeper" determinants of economic performance (such as openness to trade, geography and institutions). So he thinks of accumulation and productivity change as proximate determinants of growth at best and cross country growth differences cannot merely be explained by these proximate determinates.

[6] Much faster population growth in most developing countries is offsetting comparatively faster GDP growth, causing GDP per capita growth rates in these countries to be relatively low or even negative.
[7] http://www.worldbank.org/depweb/english/beyond/global/glossary.html

4.2. Theories of Economic Growth and Growth Accounting

4.2.1. Neo-Classical Growth Theory: The Solow Growth Model

The primary reference in economics of growth is the neoclassical paradigm[8]. And, when we talk about the neoclassical growth paradigm we shall proudly bring the Solow growth model at the front line. The Nobel Prize winning economist Robert Solow, who coined this growth model, is regarded as seminal contributor to the subject of growth theory in general and the neoclassical in particular. The very salient implication drawn out of the Solow model is that countries will conditionally converge toward the same level of income, provided they have the same rates of savings, depreciation, growth of labor force, and productivity growth, and sustained growth of per capita GDP in the long run is not possible without technological shock (Todaro, 2012).

Basically, the Solow growth model is a subtle modification of the Harrod-Domar model (a classical growth model for which no explanation is made in this paper). In the Solow model, however, two more covariates are introduced to the growth equation. Namely, labor, as a second input for which substitution with capital is possible and technology with which the two factors (labor and capital) are deployed. Additionally, under the combination of the two inputs the production function is assumed to exhibit constant returns to scale (hence the production function is homogeneous of first degree) with diminishing returns of each input, most of the time. Technological progress is a residual factor explaining long-term growth, that is, residual from income growth and factor accumulation. Unlike the endogenous growth model—to be discussed

[8] The neoclassical paradigm is successful owing to its economy of two-equation description of the growth process; (1) a production equation that relates the current flow of output goods with inputs (the current stocks of capital and labor), (2) and investment equation that shows how capital accumulation depends on investment (aggregate savings) and depreciation of capital, and for showing the impossibility of sustained per capita output growth in the long run without technological change.(See more in Aghion and Howitt,2009).

in the next section—technology or total factor productivity (TFP) is assumed by Solow to be completely exogenous, that is, independently of all other factors internal to the economic system.

Let's discuss the mathematical exposition of the Solow growth model in detail as follows:

Assume an economy producing a single commodity Y(t) of which a fraction is consumed and the rest is saved and then invested. The economy saves a fixed fraction s of output, so that the total saving is *sY(t).* The stock of capital of the economy *K(t)* is an accumulated output over time, and it depreciates by a constant δ amount every year. Net investment is then just the net addition to the stock of capital of one past year over time. More precisely, it is savings minus depreciation. Conveniently, it is dK/*dt* or $\dot{K}$, and we have the basic identity at every moment of time:

$$\dot{K} = sY(K) - \delta K = I \qquad (1)$$

And, the production function which captures the output-capital relationship is:

$$Y_t(K) = f(K). \qquad (2)$$

Equation (1) is called the Solow Investment Equation and gives the growth of capital, *K* (known as "capital deepening"), and shows that the growth of *K* depends on savings *sY*(K), after allowing for the amount of capital required to service depreciation, δK. The term $\dot{K}$ (the dot denotes the derivative of K with respect to time) in the right side of equation (1) is the continuous time equivalent of $K_t - K_{t-1}$, that is, change in capital stock between two time periods. The implication of the Solow equation thus is that increasing savings will result in higher growth of capital, which means an economy that saves more grows faster than the one

that doesn't or saves less, provided the two economies facing same rate of capital depreciation (Solow, 1957).

In summary, (1) is a differential equation in the single variable *K(t), since s and δ are constants.* Its solution (through integration) gives the time profile of the capital stock. Once we know the time path of capital stock, we can compute the corresponding time path of output from the production function (i.e., the time path of output is then determined by substituting the path of capital into the aggregate production function). Diagrammatically, given any stock of capital, the instantaneous rate of change of capital stock is the vertical distance between the savings curve and the upward sloping depreciation (straight) line.[9] Thus whenever the savings curve lies above the depreciation line, the growth of capital stock will be positive and vice versa. It will keep increasing with gradual decrement as long as savings outweigh depreciation and then becomes zero at the steady-state level of capital stock (at a nonzero capital stock) when the two curves intersect because of diminishing marginal product of capital. Needless to say, the steady-state level of growth of capital can happen at zero capital stock as well, but this level is not stable so long as initial capital stock is positive (Aghion and Howitt, 2009)

With the assumption of constant population growth and technology, Solow made a pessimistic assertion that in the long run there will be a state in which output and capital per capita are no longer changing, known as the steady-state. In other words, an economy can realize growth in capital stock and hence in output temporarily if it cuts consumption and increase saving, but in the long run this growth would come to an end at the steady-state level (Todaro, 2012).

[9] See the graphical discussion of Solow equation in Aghion and Howitt (2009), The Economics of Growth. MIT Press., p 42, figure 1.1

Now let's relax our assumption of no population growth (but we yet remain with no technology change) and find out Solow's conclusion. Assume output is produced by the use of two substitute factors of production, capital and labor, so that the production function looks like:

$$Y(K,L) = F(K,L). \qquad (3)$$

Suppose further that the production function exhibits constant return to scale (.i.e., is linear homogenous in both arguments) and is "well-behaved"—is concave--, meaning both capital and labor have diminishing contributions to the aggregate output function. In the Cobb-Douglas form the production function can be specified as follows:

$$Y(K,L) = K^{\alpha}L^{1-\alpha}. \qquad (4)$$

where $0<\alpha<1$, and it denotes the elasticity of output to changes of capital stock. In the per capita form:

$$y(k) = k^{\alpha}. \qquad (5)$$

where y and k are output and capital in per capita (worker). Then the production function in equation (5) tells us the amount of output per person produced for certain amount of capital stock per person engaged in the economy. Let's introduce some mathematics tricks here so as to use the best service of such form of production function:

$$k = \frac{K}{L} \qquad \Rightarrow \qquad \ln k = \ln K - \ln L$$

$$\dot{k} = \frac{dk}{dt}, \ \dot{K} = \frac{dK}{dt}, \ \dot{L} = \frac{dL}{dt}$$

$\frac{d \ln k}{dt} = \frac{dk}{dt} \cdot \frac{1}{k} = \frac{\dot{k}}{k}$ (doing the same for K and L in a similar fashion)[10]

$$\frac{\dot{k}}{k} = \frac{\dot{K}}{K} - \frac{\dot{L}}{L} \qquad (6)$$

In the absence of technological change assume further that labor and population grow at a same constant rate n ("Harrod's natural rate of growth"). That is, the growth rate of labor force, $\frac{\dot{L}}{L}$ is equal to n and there is full employment. Thus, we can express the labor supply curve as:

$$L(t) = L_0 e^{nt} \qquad (7)$$

where L_0 is the initial labor force[11]. Here, taking log of both sides and differentiate with respect time yields us$\frac{\dot{L}}{L}$, the rate of growth of labor force, that is n. Now let's combine equation (1) and equation (6):

$$\frac{\dot{k}}{k} = \frac{sY(K) - \delta K}{K} - n \quad (since\ \dot{K} = sY(K) - \delta K, and\ \frac{\dot{L}}{L} = n)$$

$$= \frac{sY(K)}{K} - \delta - n$$

---

[10] $\frac{d \ln K}{dt} = \frac{dK}{dt} \cdot \frac{1}{K} = \frac{\dot{K}}{K}$ and $\frac{d \ln L}{dt} = \frac{dL}{dt} \cdot \frac{1}{L} = \frac{\dot{L}}{L}$ (and are the growth rates of K and L, respect. as is $\frac{d \ln k}{dt} = \frac{dk}{dt} \cdot \frac{1}{k} = \frac{\dot{k}}{k}$ rate of growth of capital per worker.

[11] *We are looking at equation () as a supply curve of labor and it says that the exponentially growing labor force faces perfectly inelastic supply curve. The labor supply curve is a vertical line which shifts to the right in time as the labor force grows by n.* (Solow, 1956).

After some rearrangement we will get the Solow's capital accumulation equation in per capita form:

$$\dot{k} = sy(k) - (\delta + n)k \qquad (8)$$

The per capita form of Solow's capital accumulation equation gives the growth of the capital per worker, k (known as capital deepening), and shows that the growth of k depends on savings sy(k), after servicing depreciated capital, δk, and after capital widening, that is, providing the existing amount of capital per worker to the net new workers joining the labor force, nk (Todaro, 2012).

As the case of "no population growth" capital per person grows when total savings outweigh capital deepening and capital widening, but ceases once the steady state is reached. Therefore, in the long run, the country's growth rate will be zero and will depend only on the rate of technological progress, which neoclassical theory takes as exogenous.

Now we are ready to introduce a technology argument in the production function along with population growth. Likewise, as the above case output is produced with the help of two factors of production, capital and labor, and additionally technology A(t) with which the two factors (labor and capital) are deployed. Thus, we alter equation (3) to read

$$Y = A(t)F(K, L). \qquad (9)$$

The Cobb-Douglas form:

$$Y(t) = K(t)^{\alpha}[L(t)A(t)]^{1-\alpha}. \qquad (10)$$

The isoquant map remains unchanged as (3) but the output level attached to each isoquant is multiplied by $A(t)^{1-\alpha}$ here (Solow, 1956).

A(t) (represents the productivity of labor) grows over time at an exogenous rate g , and as before population at n:

$$A(t) = A_0 e^{gt}$$

$$L(t) = L_0 e^{nt}$$

As A(t) , is labor-augmenting technology, measures the technical efficiency of labor, and technically, the only difference from the previous model (with no technology) is that we have the labor input *L* everywhere replaced by the number of "efficiency units" or "effective unit "of labor *AL (Aghion and Howitt, 2009)*. We can now find a steady state in terms of capital per efficiency unit[12]. Per effective unit of labor notations of capital and output are therefore:

$$k_e = \frac{K}{AL} = \frac{k}{A} = kA^{-1}.$$

and

$$y_e = \frac{y}{AL} = yA^{-1} = k_e^{\alpha}.$$

where K_e, y_e are capital and output per efficiency unit, and k and y are capital and output per worker as before. The Solow capital accumulation equation would now become:

$$\dot{k}_e = sy_e - (\delta + n + g)k_e$$

[12] *Aghion, P., Howitt, P. (2009), The Economics of Growth. MIT Press and Mankiw, N.G., Romer, D., Weil, D.N. (1992), A Contribution to the Empirics of Economic Growth. Quarterly Journal of Economics 107(2), 407-437*

$$= sk_e^{\alpha} - (\delta + n + g)k_e \,. \qquad (11)$$

Equation (11) implies that the growth of capital per effective unit of worker is saving per efficiency unit sy_e minus the amount of depreciation of capital δk_e and the number of effective units of labor AL, which grows at the rate $n + g$, draining capital by $(n + g)k_e$. The steady state of capital per effective unit of labor k_e^* is:

$$k_e^* = \left[\frac{s}{(\delta + n + g)}\right]^{\frac{1}{1-\alpha}}. \qquad (12)^{13}$$

In summary, the Solow (1956) model shows how an economy can raise growth rate by encouraging people to consume less and save more---place large emphasis on increasing saving in the short run. But the model also predicts that such an increase in growth stops in the long run, i.e., at the steady state but growth is possible via technological advancement.

4.2.2. New Growth Theory (Endogenous Growth Theory)

Paul Romer and Robert Lucas, in the mid-1980s, are the forerunners in developing the endogenous growth theory. The claim of this growth theory stems on endogeneity of technology

[13] This is found by equating $\dot{k}_e$ to zero and rearranging equation (), as at steady state $\dot{k}_e = 0$

unlike the neoclassical growth theory. The basic difference is that in the exogenous model the steady-state growth rate is determined exogenously, i.e., technical change is independent of economic forces, whereas in endogenous one, it is determined endogenously (Aghion and Howitt, 2009). The endogenous growth theory argues that technological change is a response to economic incentives in the market that can be influenced by the government or private sector.

Technically speaking, there is no per capita growth of steady state because of the assumption of decreasing returns of capital, unless with technological shock. That is the conclusion of neoclassical growth theory and it has long been a subject of criticism, especially by the new (endogenous) growth theorists.

However, technology had been ruled out as exogenous factor in the neoclassical model. Endogenous growth theory challenges this neoclassical view by proposing channels through which the rate of technological progress, and hence the long-run rate of economic growth can rather be influenced by economic factors. The theory proposed that technological progress takes place through the introduction of new accumulation factors, such as knowledge, innovation, R& D, externalities and spillovers, many of which are results of economic activities.

Romer argued about the possibility of positive, long run growth rates on the basis of technological progress that is driven by the role of externalities through learning by doing and knowledge spillover. Whereas Lucas introduces a model in which human capital plays a fundamental role in perpetuating economic growth and preventing diminishing returns to physical capital accumulation. He precisely argued that investment in human capital, it can be in the form of education or training, makes workers more productive and efficient, and then results in human capital accumulation, and hence economic growth can be achieved. In addition, human capital accumulation will bring about spillover benefits (Aghion and Howitt, 2009).

4.3. Empirical Review

Growth accounting was started back in 1957 by Robert Solow who is regarded as the seminal contributor for the neoclassical growth literature. It has become a growing subject in economics since then. More recently the subject has got much attention after researchers such as Krugman (1994) and Young (1995) brought an amazing assertion that the East Asian growth miracle was driven primarily by factor accumulation rather than total factor productivity (TFP). There is a large body of literature in growth accounting, especially in developed countries (because of earlier availability of data), and cross-country comparison is conducted widely[14]. In SSA, there are few studies on growth accounting at the regional level and considerable amount of studies at country level. The majority of the literature in the region indicated that factor accumulation is the primary source of growth in Sub-Saharan Africa, with insignificant contribution from TFP growth. Here are some of the prior studies on growth accounting in Sub-Saharan-Africa:

Bosworth, Collins, and Chen (1995) in their paper titled "Accounting for Differences in Economic Growth", by using growth accounting and regression analysis, examined growth experience of 88 countries (both developing and advanced countries) over 1960 to 1992 time period. Their findings revealed that increase in TFP have been small in developing countries relatively and made small portion of the output growth whereas factor accumulation (physical and human capital) account for most of the per capita growth. More, the decomposition results

[14] Jorgenson (1995), Aghion and Howitt (2007), Bosworth et.al(1995), Bosworth and Collins (2003), Tahari et.al (2004)

show that in Sub-Saharan-Africa, where output per worker has increased by just an average of 0.5 percent over the entire period time (1960-1992), TFP growth has been negative (-0.5 percent, in the two factor model).

Senhadji (2000) conducted also a growth accounting exercise for 88 countries over 1960-1994 period with the objective of examining the sources of cross-country differences in TFP levels and found out that both physical and human capital accumulation and TFP growth are lower in SSA as a whole contributing to the poor performance of the region in relation to the rest.

More, Bosworth and Collins (2003) constructed growth accounts for eighty-four countries that together constitute 95 percent of world GDP and 84 percent of world population, over a period of 1960-2000. According to their findings, over the entire period (1960–2000) world output grew on average by 4 percent a year, whereas output per worker grew by 2.3 percent a year. They also showed that increases in physical capital per worker and growth in TFP each contributed roughly 1 percentage point a year to per worker GDP growth, while increased human capital (education attainment) contributed about 0.3 percentage point a year.

At the regional level East Asia (excluding China) has been the fastest-growing region, with output per worker growth of 3.9 percent a year, while Sub-Saharan Africa was the slowest-growing region over 1960 to 2000 period as a whole. In SSA output per worker grew just by 0.6 percent a year, and in component terms growth in capital per worker contributed only 0.5 percentage point a year to growth in output per worker, which is half the global average (i.e., 1 percent). The primary culprit in Africa's slow growth is however, TFP, which declined in every decade after 1970 and roughly nil during the entire period of 1960-2000 (-0.1 percent growth a year, on average).

Tahari et.al (2004) worked on source of growth in SSA countries, by analyzing data between 1960 and 2002, show that average real output growth was low and decreased continuously and started recovering in the second part of the 1990s. Factor accumulation, with little role for total factor productivity (TFP) growth, primarily explained output growth in the region. Average annual growth of output in the region was 3.5 percent during 1997-2002, which is less than half of the estimated growth needed to halve the fraction of population living below $1 per day between 1990 and 2015, one of the Millennium Development Goals. Out of such growth 3.2 percent was contributed for by factor accumulation and TFP growth contribution was nil on average, despite an increase in TFP growth accompanied the recent rise in economic growth.

To sum up, all of the related priori works indicated that the source of output growth in SSA countries as a whole is factor accumulation with a little or no role for TFP improvements, and I also hypothesized that there will not be different explanation for the source of growth in SSA other than factor accumulation.

5. METHODOLOGY

The neoclassical growth accounting methodology, according to which the contribution of inputs to output growth is measured as a weighted (by GDP shares) averages of input growth and the growth of TFP is computed as residual from the growth of output, is employed. The study particularly closely looks at the trend of GDP growth, capital stock and employed labor and technology in SSA countries and makes comparisons of growth of these elements at subgroup

levels and income subgroups of SSA.

5.1. Growth accounting and Aggregate Production Function

The objectives of this study are to estimate the aggregate production function and to determine sources of economic growth in SSA countries in 1980-2011 time period by using the growth accounting framework. More precisely, this paper studies economic growth overtime of each country and cross-country output differences. Growth accounting helps us break down economic growth into its components of factor accumulation and productivity growth or Solow residual, which reflects technological progress and other elements (Barro, 1998). For estimation of the production function and the growth accounting, I imposed assumptions of perfect competition and the production function is Cobb-Douglas exhibiting constant returns to scale.

Growth accounting in its basic form assumes a familiar Cobb-Douglas aggregate production functions, such that in the general form:

$$Y(t) = A(t)K^{\propto}(LH)^{1-\propto} \quad , \quad 0 < \propto < 1 \tag{13}$$

$$Y(t) = A(t)K^{\propto}\mathrm{L}^{1-\propto} \quad , \quad 0 < \propto < 1 \tag{14}$$

where dropping time dependence, Y is real GDP, K is physical capital stock, L is number of employed labor and H is measure of human capital and $\propto$ is the share of capital income (the price of capital times the quantity K) in national income (Y). Unlike in equation (13) labor force series is not adjusted for human capital in equation (14); thus in this design, human capital accumulation is part of TFP. We assume perfect competition so that the remuneration of each input is equal to their corresponding marginal product. Accordingly, $\propto$ usually is taken equal of income share of capital in national income and so too 1-$\propto$ income shares of labor in national

income, taken from the national accounts of individual countries.

We assume A(t) is a parameter that captures disembodied technological shifts and grows at a constant exogenous rate. This form of technical change is also called "Hicks-neutral" and is "output augmenting" when it raises the maximum output that can be produced with a given level of capital and labor, and without altering the relationship between the two inputs[15].

We can also rewrite equation (13) in per capita form or in the intensive form:

$$\frac{Y(t)}{L(t)} = y(t) = Ak^{\alpha}H^{1-\propto} \qquad (15)$$

where y(t) (or henceforth y, dropping time dependence) and k are per capita output and capital (capital stock per worker), respectively. Logarithmic transformations of equation (13) and (15) yield:

$$\ln(\mathrm{Y}) = \ln \mathrm{A} + \alpha \ln(\mathrm{K}) + (1-\alpha)\ln(\mathrm{LH}) \qquad (16)$$

$$\ln(\mathrm{y}) = \ln \mathrm{A} + \alpha \ln(\mathrm{k}) + (1-\propto)\ln(H) \qquad (17)$$

after deducting $\ln(H)$ from both sides of (17) and rearranging we get:

$$\ln(\mathrm{ye}) = \ln \mathrm{A} + \alpha \ln(\mathrm{ke}) \qquad (17a)$$

where ye and ke are output and capital per effective labor unit LH, respectively.

Time being continuous we can find the growth rate of GDP and per capita GDP through

[15] See "Measuring Productivity, OECD Manual", (2001) for more detail about the distinction between embodied and disembodied technical change, especially the first three chapters

differentiation of these equations with respect to time.[16] Thus, we get

$$g_Y = g_A + \alpha g_K + (1-\alpha) g_{LH} \qquad (18)$$

$$g_y = g_A + \alpha g_k + (1-\alpha) g_H. \qquad (19)$$

where $\dot{Y}, \dot{A}, \dot{K}, \dot{L}, \dot{y}$ and $\dot{k}$ are derivatives of each parameter with respect to time. Equation (16) and (17) are used for the estimation of the aggregate production function, whereas equation (18) and (19) for the growth accounting analysis. We can also modify (19) to look:

$$g_{ye} = g_A + \alpha g_{ke}. \qquad (19a)$$

where g_{ye} and g_{ke} are growth rates of output and capital stock per effective labor unit (LH).

However, the per capita form (equation (17) and 17a) are used for the estimation of the aggregate production function over the general form (equation (16)), (just for simplicity) or for its consistency with the assumption of imposition of constant returns to scale restriction and for economy (in terms of minimizing estimation bias) in the estimation of the production function as labor and capital usually possibly have high correlation overtime.

Growth accounting is not simple as all of the variables in the above equations could not be observed directly. For almost all of the SSA countries we have time-series data on output, capital, and labor (and for some human capital), so that we observe g_Y, g_K and g_{LH} but we do not have direct measures of A and α. In growth accounting we solve this problem in two steps:

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[16] $\frac{d\ln(Y)}{dt} = \frac{d\ln A}{dt} + \alpha\frac{d\ln(K)}{dt} + (1-\alpha)\frac{d\ln(LH)}{dt}$, then $\dot{Y}/_Y = \dot{A}/_A + \alpha\,\dot{K}/_K + \alpha\,\dot{LH}/_{LH}$ ----the general form
$\frac{d\ln(y)}{dt} = \frac{d\ln A}{dt} + \alpha\frac{d\ln(k)}{dt} + (1-\alpha)\frac{d\ln(H)}{dt}$, then $\dot{y}/_y = \dot{A}/_A + \alpha\,\dot{k}/_k + (1-\alpha)\,\dot{H}/_H$---------the intensive form

First find the value of α from the national accounts or can be found once the aggregate production function is estimated. However, in line with the literature on aggregate production function estimates for developing countries[17], I take α = 0.4 (because national accounts in SSA countries are not produced regularly and my estimation seems to have exaggerated value of α=0.7). Secondly estimate TFP growth (g_A) using a 'residual' method.

To compute TFP let's just rewrite the growth accounting equation (19) as:

$$g_A = g_y - \alpha g_k - (1-\alpha) g_H . \qquad (20)$$

Equation (20) shows that the rate of TFP growth (g_A) is the residual left over from the difference of the observed growth rate of output per capita g_y, capital-deepening term (g_k) and human capital accumulation growth g_H. This estimate of TFP growth is known as the 'Solow residual'.

5.2. Data and definition of variables

5.2.1. Data: Source and Sample Size

The data are mainly composed from Penn World Tables 8.1 series[18], for all countries and for 1980-2011 time lapse. I am working on SSA countries, these countries are 48 in total according to the (July 2015) World Bank classification of economies[19]. However, only 43 countries are studied because data cannot be accessed for Eritrea, Seychelles, São Tomé and Principe, South Sudan and Somalia. While data for capital stock, employed labor and real GDP are available for

[17] Bosworth, Collins, and Chen (1995) provide empirical support for this value.
Senhadji (2000) finds a mean value of 0.43 for group of countries from sub-Saharan Africa.
[18] http://www.rug.nl/research/ggdc/data/pwt/pwt-8.1
[19] siteresources.**worldbank**.org/DATASTATISTICS/Resources/CLASS.XLS

those 43 countries, human capital data is available only for 32 countries, thus Angola, Burkina Faso, Cape Verde, Chad, Comoros, Equatorial Guinea, Ethiopia, Guinea, Guinea-Bissau and Madagascar have no data of human capital. That means the regression carried out using human capital rules out these countries.

Data values are in millions, at constant 2005 national prices and in constant $US, but labor is in number of people engaged in employment in million.

5.2.2. Definition of Variables

This section is devoted to the discussion of the definition of variables used in the regression and growth accounting, and also explanation for how they are measured. Oftentimes, the variables of interest in aggregate production function estimation and growth accounting exercise, as well known, are output, labor and physical capital, and human capital (if data is available).. Here are the definitions of them as follows:

Real GDP: it is taken as a proxy for output and is at constant 2005 national prices, obtained from national accounts data for each country. It is reported by Penn World Tables as real gross domestic product (GDP) at constant (2005) national prices $RGDP^{NA}$ and is calculated as GDP converted into international dollars using purchasing power parity (PPP) rates.

Capital: Capital stock at constant (2005) national prices, based on investment and prices of structures and equipment. It is an accumulated and depreciation accounted past investments, estimated using perpetual inventory method, and reported in Penn World Tables as RK^{NA}.

Labor: Is defined by Penn World Tables as number of persons engaged in production, aged 15

years and over, who during the reference week performed work, it could be even just for one hour a week, or were not at work but had a job or business from which they were temporarily absent.

Human Capital: Human capital is included to adjust the labor input (to account for quality difference of labor in a country and across regions). Penn World Tables put it as an Index, index of human capital per person, constructed based on years of schooling (Barro/Lee, 2012) and returns to education (Psacharopoulos, 1994).

Per capita GDP and capital: these variables are defined with the assumption that total population and total employed labor are growing at same rate annually in the economy of interest. Thus, per capita GDP is the difference between the growth of output and the growth of labor and similarly per capita capital is the difference between the growth of capital stock and the growth of labor (or population).

6. RESULTS AND DISCUSSION

This section discusses about the analysis results of estimation of aggregate production function and growth accounting exercise.

6.1. Econometrics Analysis: Estimation of aggregate production function

The only reason for undertaking objective of estimation the aggregate production function is to compute the capital share of income and compare with the conventionally allotted value of 0.35-0.4 for developing regions such as Sub-Saharan-Africa, as I failed to access data for rental price and wage payments to compute capital share using these factor prices. The aggregate production function is estimated for 43 SSA countries (as cross-sectional dimension) and 32 years of time dimension, with a strongly balanced data, of output (GDP), capital stock and labor, with the Cobb-Douglas specification in which perfect competition and constant return to scale are assumed. Additionally, the production function is estimated with adjusted labor for 32 countries that have human capital data in order to split TFP and human capital deepening contributions.

In other words, undertaking the estimation of the aggregate production function helps us find the elasticity of per capita GDP with respect to per capita capital and labor. The Hausman test tells us that random-effects estimation should be used over fixed-effects. Table 1 provides the aggregate production estimation results for SSA countries (total), and at subgroup levels of low income, lower middle income, upper middle income and high income[20]. In this case the estimation is carried out with unadjusted labor, in the intensive form. However, Table 2 provides the estimation result with adjusted labor.

As we can see from Table 1 &2 the share or elasticity of capital ($\propto$) seems to be so strangely high, so inconsistent with previously estimated values by Bosworth, Collins, and Chen (1995) and Senhadji (2000). These strange set of capital share values are not coincidental I say, rather they reflect the odd nature of markets in the region on top of overestimated data. In fact, the

[20] As high income group contains only one country the estimation it should be noted clearly that the estimation of this group is not done using random-effects unlike the rest of the groups. It is rather estimated through OLS so that direct comparison with the other groups is not valid or sensible.

SSA's data should not be free from suspect. This African region is long known for its government sponsored monopolies, especially in markets of public utilities such as electricity, telecommunication, water etc. which are always being reported of high inefficiency. I believe, these characteristic of Sub-Saharan-African markets in addition to rampant and big informal sector and high agriculture population that are engaged in self-employment (and even if data of this sector is reported, it is not free of doubt) might inflate the share of capital in the national incomes so that it makes the estimation unconventionally bizarre.

In addition, we should point our index finger at the employment data in particular let alone how difficult and problematic is "accurate "measurement of capital stock. The employment data in this paper is reported as total number of people engaged in production regardless of the number of hours worked. That means a person that has worked half an hour per day has got equal weight as the person who has worked 16 hours a day in the dataset. More, a person who has managed to get job for today might not be working tomorrow---such cases are so rampant in SSA as temporary employment and lay off are so common. Workers may face a longer unemployment spell in such on and off employment practice. Therefore, the reported employment data is exaggerated which means it has largely disguised unemployment and this makes the share of labor in the national income less and capital's higher. Lastly, the mention of these possible reasons, however, is just for the explanation of high capital share, not to claim or indicate that the share of capital is this much high in the region. Further study in the subject (specially with labor data measured in hours of work not in number of workers) and closer scrutiny of the Penn World Tables data of the region should be done in the future.

6.2. *The Decomposition of Output Growth in Sub-Saharan-Africa*

Growth accounting breaks down output growth into growth in factor inputs and total factor productivity, the former with weights of output shares. As in John (1994), Bosworth, Collins, and Chen (1995) and Senhadji (2000), I assign a weight of 0.4 to capital share in the computation of the changes in factor accumulation for all groups of countries in SSA. All of them justified that the share of capital is larger than the share in developed countries owing to the fact that labor's share of total income is lower in developing countries. "*Part of the difference is attributable to a larger proportion of self-employment in developing economies: the labor component of self-employment income is assigned to capital income in the national accounts" (*Bosworth, Collins, and Chen, 1995).

I have done the growth decomposition in two designs: one factor input growth consisted of labor and the other with adjusted labor. In other words, the growth accounting has TFP and capital deepening components in the first case and additionally it has human capital accumulation component in the second case. The two growth accounting exercises are:

$$(1)\ g_A = g_y - \alpha g_k .$$

$$(2)\ g_A = g_y - \alpha g_k - (1-\alpha) g_H .$$

In (1) total factor productivity also includes human capital accumulation in it, and the growth accounting is calculated for 43 countries and at subgroup level, countries are grouped according to income status into four groups. The subgroup is consisted of low income, lower middle

income, upper middle income and high income countries. Growth accounting is also computed using (2), here the number of countries is 32, 9 countries are dropped that do not have human capital data. Here TFP and human capital accumulation are reported separately. Like in (1), the accounting is also computed at subgroup level. However, we do not have high income group in case of (2), because this group only contains the country of Equatorial Guinea that does not have data of human capital.

A summary of the results of (1) & (2) is provided in Table 8-11. More specifically, (1) is summarized in Table 8 &10, whereas (2) is summarized in Table 9&11. All of the variables are reported in average annual growth rates. The main variables of interest to talk are annual growth of output (or per worker) and its components: the estimated growth in TFP, capital deepening and human accumulation, over the period of 1980-2011.

The main results from growth accounting exercises for individual countries and for subgroups of countries over the period 1980-2011 are discussed below.

The performance of the SSA region as a whole was weak during 1980-2011, barely 0.8 percent average growth in per capita GDP or 3.7 percent in real GDP. It has slightly increased from the region's 3.3 percent growth rate of GDP over 1960-2002 (Tahari et.al, 2004). The rising oil prices in the recent decades and cease of conflicts in many African countries that were in a prolonged chaos for long are the explanations. No country has experienced negative annual average growth in the region in the entire time period, all the countries have experienced an annual average of more than 1.2 percent except Democratic Republic of the Congo that had 0.5 percent GDP growth. There is one country that has enjoyed remarkable double-digit GDP growth that is oil rich Equatorial Guinea with a magnificent 14.1 percent followed by Botswana

by 7.7 percent.

The average TFP growth was 0.6 percent in the region, during the same period, contributing to the poor overall growth performance of the region. This amounts 15 percent of overall GDP growth and 75 percent of per capita GDP growth of the region. More than one-third of the countries in the region experienced declines in TFP on average during 1980-2011. About 30 percent of the countries experienced an average TFP growth of less than 1 percent but positive and 20 percent of the countries in the region experienced between 1 and 2 percent TFP growth. Only five countries (Botswana, Equatorial Guinea, Mauritius, Cape Verde and Chad) experienced an average TFP growth of more than 2 percent over 1980-2011 time period. At the country level, Equatorial Guinea has again the lead, 4 percent annual TFP growth on average. One thing we have to note in our discussion of TFP is that the TFP we talking here also includes human capital component.

The factor accumulation in the region was about 3.1 percent during the same period (capital and labor grew by 3.5 and 2.9, respectively), and capital deepening was 0.2 percent[21]. Capital deepening had 25 percent share of the average per capita GDP growth of the region, while the share of factor accumulation in average GDP growth was 85 percent. Almost half of the SSA countries experienced negative growth in capital deepening over the entire time period, the civil-war torn apart (in 1989-96) Liberia witnessed the worst capital deepening (-1.4 percent). Only 8 countries (Botswana, Burkina Faso, Cape Verde, Equatorial Guinea, Lesotho, Rwanda, Sudan and Uganda) have experienced capital deepening growth of more than 1 percent during 1980-

[21]Factor accumulation is sum of the growth rates of capital and labor (weighted by their respective output shares). Capital deepening is an increase in capital per worker, the difference of the growth rates of capital and labor weighted by share of capital. Mathematically, capital deepening = $\alpha(g_K - g_L)$, and factor accumulation = $\alpha g_K + (1-\alpha)g_L$= $\alpha(g_K - g_L)$+g_L= capital deepening + g_L.

2011. Again here Equatorial Guinea is the leading, experiencing about 6 percent impressive average growth in capital deepening.

At the subgroup level upper middle income countries performed better than the rest, excluding the high income group which is a one country group (i.e., Equatorial Guinea). These group of countries, which are 6 in number, experienced 4.3 percent growth in real GDP on average over 1980-2011 time period. The growth of GDP is decomposed into 3.4 percent of factor accumulation and 0.9 percent TFP growth. The low income countries did not perform top in the subgroup despite this group is consisted of 23 countries. In neoclassical supposition of convergence, this group of countries should have experienced the fastest growth amongst. Factor accumulation accounted for by 90 percent of real GDP growth in this category whereas the rest 10 percent by TFP.

In summary, the overall performance of the sub-Saharan African region is negligible during 1980-2011 time period, the region has experienced just 0.8 percent growth in per capita GDP, reflecting the fact that the region has suffered from many conflicts and civil wars.[22] This growth was composed of 0.2 percent capital deepening and 0.6 percent TFP components. The region's real GDP growth was 3.7 percent that is decomposed into 3.1 percent of factor accumulation contributions and 0.6 percent of TFP contributions over 1980-2011. Thus this shows that average real GDP growth in the region during 1980-2011 was driven primarily by factor accumulation (85 percent) with little or no role for TFP (15 percent share), although TFP included human capital contributions as well. Unlike in the previous studies, TFP constitutes a big portion of per capita output growth in the region, it accounts 75 percent (0.6 out of 0.8

[22] For instance, Cote d'ivoire, Angola, Liberia, Sudan, Dem. Rep. Congo, etc. are amongst which have prolonged civil wars.

percentage points) for the per capita output growth although human capital effect is buried in TFP. At the country level, the oil rich, non-OECD rich country of Equatorial Guinea leads the region in terms of impressive growth and at the subgroup level upper middle income countries' performance was better followed by lower middle income, in the absence of the high income category.

In the above discussion we have worked with unadjusted labor, that is, the labor force series was not adjusted for human capital stock thus human capital was part of TFP. But it turns out that the huge chunk of the TFP is human capital accumulation--is the result of educational attainment. The next discussion is about growth accounting with human capital included as separate argument in the production function, not part of TFP. The results of such analysis are provided in Table 9 &11.

Before we get into the discussion we should be aware that the direct comparison of the results of the discussion above and what we discuss below is not possible or sensible. Because, the number of countries here are 32 whereas in the above discussion they are 43, we have such split because there was no human capital data in latter. Therefore, hereafter SSA refers the aggregate of 32 countries.

The region as whole performed weakly, the average per capita GDP growth was 0.5 percent during 1980-2011. Out of this growth, the largest part is contributed by human capital accumulation which is 0.6 percent on average. Whereas capital deepening and TFP had 0.1 and -0.2 average growth rates, respectively. At the country level, Botswana that had 4.2 percent average per capita GDP growth took the lead (Equatorial Guinea is not included in this particular analysis). This country led the region in human capital accumulation too, 1.2 percent growth in

human capital accumulation—the only country with more than 1 percent human accumulation growth (see Table 9).

As we can see from Table 9, human capital accumulation took the largest percentage share of the per capita output growth. Surprisingly, the whole per capita growth is accounted for by human capital accumulation in this particular setting of the region. The average growth of per capita GDP, as I mentioned above is 0.5 percent and human capital accumulation growth is 0.6 percent which is more than 100 percent of the per capita GDP growth.

7. CONCLUSIONS AND SUMMARY

The objective of this paper is to estimate aggregate production function and compute growth accounting of SSA countries in the time period of 1980-2011. For the former random effects estimation of production function is carried out both at the aggregate level (SSA wholly) and subgroup levels of low income, lower middle income, upper middle income and higher income countries. The main findings of this paper therefore are put as follows:

- The overall performance of the sub-Saharan African region is not impressive during 1980 to 2011 period, the region has experienced just 0.8 percent growth in per capita GDP, reflecting the fact that the region has suffered from many conflicts and civil wars. When

this growth is decomposed, it is composed of 0.2 percent capital deepening and 0.6 percent TFP growth. Real GDP growth in the region was 3.7 percent with 3.1 percent factor accumulation and 0.6 percent TFP growth decomposition. Thus this shows that average real GDP growth in the region during 1980-2011 was mainly driven by capital deepening or factor accumulation with relatively little role for TFP (even when human capital contributions are buried in TFP). The literature says the contribution of TFP improvements in the region has been nil, but that is not true anymore. Because in this study we have evidence that TFP is not insignificant at all in terms of contributing to the overall output growth the region. TFP growth made 15 percent of the regions output growth and 75 percent of the per capita growth, and have grown drastically across decades. For example, TFP growth was high during 2002-2011 lapse, that is, 1.4 percent average growth of TFP was witnessed. Hence, we cannot say TFP contribution is not substantial anymore although human capital is the whole explanation for the growth of TFP.

- The region experienced negative per capita growth in 1980-1990 period but thereafter witnessed continuous positive growth in the two decades, 1990-2001 and 2002-2011 periods.
- At the subgroup level, upper middle and high countries grew faster than low and lower middle income countries. According to the convergence prediction of the Solow model however lower income countries should have grown faster instead to catch up. Surprisingly, the whole SSA region's growth accounting results happen all to be exactly the same as the lower middle income group's (see Table 10). This means only the low income group can explain everything about the region, ceteris paribus. At the country

level, countries in upper middle income and high income levels performed better, and Equatorial Guinea[23] has performed best of all.

- The growth rate of TFP in the region as a whole appears to be procyclical—it is positively correlated with real GDP growth. On top of that, a rising in the TFP growth is noticeable since the second half of the 1990s (see figure 1).
- The growth accounting computation for 32 SSA countries with inclusion of human capital data reveals that TFP growth is nothing but human capital accumulation—educational attainment. In the framework of separate analysis of TFP and human capital in the growth accounting, I found out that human capital accumulation accounted greatly for the per capita GDP growth.

To sum up, in the region as a whole both output and TFP have grown overtime. However, there are growth differences across time and subgroups. TFP has contributed moderately for output growth so the whole explanation of output growth in the region cannot be factor accumulation only. Thus, the old image of TFP being nil in the region is not correct anymore. Moreover, TFP improvements have been changing differently across time periods and subgroups. On average the growth of TFP was negative in the first decade, 1980-1990, (i.e., -0.1 percent), but it grew positively thereafter in the rest decades. Without a separate account of TFP and human capital, the growth of TFP was 0.4 percent in 1991-2001 and 1.4 percent in 2002-2011 period. At the subgroup level as well TFP has shown a positive trend overtime. On average, low income countries have experienced lesser TFP growth (0.4 percent) than all the other subgroups, and

[23] *"Equatorial Guinea is a small country on the west coast of Africa which struck oil in 1995 and which is now being cited as a textbook case of the resource curse - or the paradox of plenty" (http://www.bbc.com/news/world-africa-13317174)*

high income group (Equatorial Guinea) took the lead with 3.8 percentage TFP growth during the entire period.

8. APPENDICES

Table 1. Estimation of Aggregate Production Function 1980-2011

	SSA	low income	lower middle income	upper middle income	high income
lnk	0.65***	0.66***	0.37***	0.93***	0.70***
	(0.01)	(0.03)	(0.03)	(0.05)	(0.02)
_cons	2.49***	2.17***	5.17***	-0.15	3.48***
	(0.15)	(0.30)	(0.26)	(0.49)	(0.16)
N	1376	736	416	192	32

Table 2. Estimation of Aggregate Production Function with adjusted labor 1980-2011

	SSA	low income	lower middle income	upper middle income
lnke[@]	0.63***	0.75***	0.41***	0.88***
	(0.02)	(0.10)	(0.02)	(0.03)
_cons	2.46***	1.30	4.42***	0.39
	(0.20)	(0.78)	(0.22)	(0.31)
N	1024	512	352	160

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

@ ke=K/LH and our dependent variable is lnye, where ye=Y/LH

Table A: Growth accounting in SSA countries by subgroup and decades

	GDP growth	*Contribution of*		
		Capital	Labor	TFP
Low Income Countries(23)				
1980-1990	2.0	1.0	1.6	-0.4
1991-2001	2.7	0.8	1.7	0.2
2002-2011	4.9	1.7	1.9	1.3
1980-2011	3.2	1.1	1.7	0.4
Lower Middle Income(13)				
1980-1990	2.9	1.1	1.7	0.1
1991-2001	3.2	1.0	1.8	0.4
2002-2011	4.7	1.9	1.5	1.3
1980-2011	3.6	1.3	1.7	0.6
Upper Middle Income(6)				
1980-1990	4.2	1.4	1.9	1.0
1991-2001	3.5	1.5	1.9	0.0
2002-2011	5.1	1.8	1.5	1.8

1980-2011	4.3	1.6	1.8	0.9
High Income Country(1)				
1980-1990	2.2	1.6	4.1	-3.5
1991-2001	26.9	14.6	1.6	10.3
2002-2011	13.1	6.2	2.1	4.6
1980-2011	14.1	7.5	2.6	3.8
Sub-Saharan-Africa(43)				
1980-1990	2.6	1.1	1.7	-0.1
1991-2001	3.5	1.3	1.8	0.4
2002-2011	5.1	1.9	1.7	1.4
1980-2011	3.7	1.4	1.7	0.6

Table B: Growth accounting in SSA countries by subgroup and decades with Adjusted Labor

		Contributions of			
	GDP growth	*Capital*	*Labor*	*Human Capital*	*TFP*
Low Income(16)					
1980-1990	1.9	0.9	1.6	0.6	-1.2
1991-2001	2.5	0.7	1.7	0.5	-0.4
2002-2011	4.9	1.5	1.9	0.6	0.9
1980-2011	3.1	1.0	1.7	0.6	-0.3
Lower Middle Income(11)					
1980-1990	3.1	1.0	1.8	0.6	-0.3
1991-2001	3.0	1.1	1.8	0.6	-0.5
2002-2011	4.2	1.9	1.5	0.4	0.4
1980-2011	3.4	1.3	1.7	0.6	-0.2
Upper Middle Income(5)					
1980-1990	4.6	1.4	1.9	1.2	0.1
1991-2001	3.7	1.4	1.9	0.5	-0.1
2002-2011	3.9	1.9	1.4	0.4	0.1

1980-2011	4.1	1.6	1.7	0.7	0.0
Sub-Saharan-Africa(32)					
1980-1990	2.7	1.0	1.7	0.7	-0.7
1991-2001	2.9	0.9	1.8	0.5	-0.4
2002-2011	4.5	1.7	1.7	0.5	0.6
1980-2011	3.3	1.2	1.7	0.6	-0.2

Table 3. Sub-Saharan Africa: Average Annual Real GDP Growth by decades, 1980-2011

	1980-1990	*1991-2001*	*2002-2011*	*1980-2011*
SSA	2.6	3.5	5.1	3.7
Angola	2.5	2.0	11.5	5.2
Benin	3.9	5.1	3.6	4.2
Botswana	12.3	6.2	4.4	7.7
Burkina Faso	2.1	5.4	5.7	4.4
Burundi	3.7	-1.2	4.6	2.3
Cameroon	1.2	2.0	3.3	2.1
Cape Verde	5.3	6.7	6.0	6.0
Central African Republic	0.5	1.9	1.5	1.3
Chad	4.5	4.3	8.7	5.7
Comoros	3.1	1.6	1.9	2.2
Congo	6.1	1.7	4.8	4.2
C™te d'Ivoire	0.5	2.3	0.7	1.2
Democratic Republic of the Congo	1.1	-5.1	5.9	0.5
Equatorial Guinea	2.2	26.9	13.1	14.1
Ethiopia	2.6	3.5	9.0	5.0
Gabon	2.2	1.6	2.3	2.0
Gambia	4.1	3.5	4.1	3.9

Ghana	2.1	4.4	6.7	4.3
Guinea	3.1	4.0	2.5	3.2
Guinea-Bissau	1.2	1.3	3.0	1.8
Kenya	4.4	2.1	4.2	3.6
Lesotho	3.4	4.0	3.7	3.7
Liberia	-5.4	8.0	3.4	2.0
Madagascar	0.7	2.2	2.3	1.7
Malawi	2.4	2.0	6.1	3.4
Mali	3.1	4.8	4.8	4.2
Mauritania	1.2	3.1	5.2	3.1
Mauritius	4.7	5.0	4.1	4.6
Mozambique	0.1	7.0	7.5	4.8
Namibia	1.5	4.0	5.0	3.4
Niger	-1.1	2.9	4.4	2.0
Nigeria	-0.1	2.4	9.0	3.6
Rwanda	2.5	3.4	8.2	4.6
Senegal	2.6	3.2	3.9	3.2
Sierra Leone	2.7	-4.9	7.9	1.7
South Africa	2.0	1.9	3.6	2.5
Sudan	2.7	6.2	6.2	5.0
Swaziland	6.2	2.8	2.3	3.8
Togo	1.0	1.0	2.8	1.6
Uganda	3.4	7.1	6.9	5.8
United Republic of Tanzania: Mainland	2.5	4.3	7.0	4.5
Zambia	1.5	1.0	5.7	2.7
Zimbabwe	5.0	0.6	0.4	2.1

Source: Own computation of data from Penn World Tables 8.1

Table 4. Sub-Saharan Africa: Average Annual capital stock Growth by decades, 1980-2011

	1980-1990	1991-2001	2002-2011	1980-2011
SSA	2.7	3.2	4.7	3.5
Angola	2.1	5.8	3.1	3.7
Benin	2.5	2.4	4.1	3.0
Botswana	9.1	7.5	6.7	7.8
Burkina Faso	7.2	5.0	5.3	5.9
Burundi	5.2	1.6	4.0	3.6
Cameroon	3.7	1.2	3.9	2.9
Cape Verde	4.5	4.4	7.4	5.4
Central African Republic	-0.2	0.0	0.2	0.0
Chad	0.9	3.1	10.7	4.7
Comoros	3.8	0.9	0.7	1.9
Congo	7.7	1.6	5.8	5.0
C™te d'Ivoire	1.6	-0.3	-1.0	0.1
Democratic Republic of the Congo	5.9	-0.3	2.8	2.8
Equatorial Guinea	4.0	36.6	15.5	18.8
Ethiopia	3.0	1.5	5.4	3.2

Gabon	1.8	0.4	2.0	1.4
Gambia	4.0	5.6	6.8	5.4
Ghana	-0.5	1.3	4.8	1.8
Guinea	3.0	4.0	8.6	5.1
Guinea-Bissau	2.3	0.9	-0.6	0.9
Kenya	2.2	2.4	5.4	3.3
Lesotho	7.8	7.1	2.4	5.9
Liberia	-1.4	-0.8	-0.5	-0.9
Madagascar	1.2	0.5	4.4	2.0
Malawi	1.3	0.4	4.7	2.0
Mali	4.3	3.5	3.6	3.8
Mauritania	2.6	1.4	8.2	3.9
Mauritius	3.3	4.1	4.4	4.0
Mozambique	1.7	4.1	6.0	3.9
Namibia	1.5	3.5	6.1	3.6
Niger	0.0	-0.4	2.3	0.6
Nigeria	1.4	-0.8	2.4	1.0
Rwanda	6.4	1.7	8.1	5.3
Senegal	1.2	2.1	4.5	2.5
Sierra Leone	2.1	-0.7	2.4	1.2
South Africa	3.0	1.7	4.5	3.0
Sudan	0.3	10.6	14.8	8.4
Swaziland	3.5	1.8	-0.6	1.6
Togo	1.7	-0.2	2.2	1.2
Uganda	2.5	6.3	8.7	5.7
United Republic of Tanzania: Mainland	0.7	2.3	6.8	3.1
Zambia	-1.5	0.7	5.1	1.3
Zimbabwe	0.4	1.6	-0.6	0.5

Source: Own computation of data from Penn World Tables 8.1

Table 5. Sub-Saharan Africa: Average Annual labor Growth by decades, 1980-2011

	1980-1990	1991-2001	2002-2011	1980-2011
SSA	2.9	3.0	2.8	2.9
Angola	3.6	3.2	3.3	3.4
Benin	2.7	3.3	3.5	3.2
Botswana	3.6	3.7	2.3	3.2
Burkina Faso	2.0	2.5	2.9	2.4
Burundi	3.1	0.6	4.0	2.5
Cameroon	2.5	3.2	2.8	2.8
Cape Verde	1.4	3.4	3.2	2.7
Central African Republic	2.4	2.5	2.1	2.4
Chad	2.2	3.2	3.2	2.9
Comoros	3.0	3.6	3.0	3.2
Congo	3.0	3.4	3.0	3.2
C™te d'Ivoire	4.3	2.9	1.7	3.0
Democratic Republic of the Congo	2.7	3.2	3.2	3.0

Equatorial Guinea	6.8	2.7	3.5	4.3
Ethiopia	3.3	3.0	2.8	3.1
Gabon	2.4	2.6	2.9	2.6
Gambia	4.2	3.1	3.3	3.5
Ghana	3.2	4.0	2.4	3.2
Guinea	2.5	3.6	2.3	2.8
Guinea-Bissau	1.9	2.4	2.7	2.3
Kenya	4.0	2.9	2.4	3.1
Lesotho	2.2	2.0	0.7	1.6
Liberia	1.0	3.4	3.7	2.7
Madagascar	2.8	3.2	3.5	3.2
Malawi	3.0	1.8	3.5	2.8
Mali	1.2	3.0	3.5	2.6
Mauritania	2.9	3.9	3.8	3.6
Mauritius	2.3	1.7	1.2	1.7
Mozambique	1.3	3.5	2.7	2.5
Namibia	4.3	3.8	3.6	3.9
Niger	3.2	4.6	3.7	3.8
Nigeria	2.3	2.4	2.4	2.4
Rwanda	2.8	2.2	3.0	2.7
Senegal	2.5	3.3	3.2	3.0
Sierra Leone	2.0	0.6	3.7	2.0
South Africa	2.9	4.2	1.8	3.0
Sudan	1.7	3.3	3.2	2.7
Swaziland	3.5	2.2	1.7	2.5
Togo	3.4	3.7	3.1	3.4
Uganda	3.2	2.9	3.0	3.0
United Republic of Tanzania: Mainland	3.0	3.1	2.8	3.0
Zambia	3.3	2.6	2.1	2.6
Zimbabwe	4.4	3.4	2.0	3.3

Source: Own computation of data from Penn World Tables 8.1

Table 6. SSA: Average Growth Rates by Subgroups and Decades

	GDP Growth	*Capital Growth*	*Labor Growth*
Low Income Countries(23)			
1980-1990	2.0	2.5	2.7
1991-2001	2.7	1.9	2.9
2002-2011	4.9	4.2	3.1
1980-2011	3.2	2.9	2.9
Lower Middle Income(13)			
1980-1990	2.9	2.7	2.8
1991-2001	3.2	2.6	3.0

2002-2011	4.7	4.8	2.5
1980-2011	3.6	3.4	2.8
Upper Middle Income (6)			
1980-1990	4.2	3.5	3.2
1991-2001	3.5	3.8	3.2
2002-2011	5.1	4.5	2.5
1980-2011	4.3	3.9	3.0
High Income Country(1)			
1980-1990	2.2	4.0	6.8
1991-2001	26.9	36.6	2.7
2002-2011	13.1	15.5	3.5
1980-2011	14.1	18.7	4.3
Sub-Saharan-Africa(43)			
1980-1990	2.6	2.7	2.9
1991-2001	3.5	3.2	3.0
2002-2011	5.1	4.7	2.8
1980-2011	3.7	3.5	2.9

Table 7. SSA: Average Growth Rates by Subgroups and Decades with human capital

	GDP	*Capital*	*Labor*	*Human Capital*
Low Income				
1980-1990	1.9	2.2	2.7	1.0
1991-2001	2.5	1.7	2.8	0.8
2002-2011	4.9	3.8	3.2	1.0
1980-2011	3.1	2.5	2.9	0.9
Lower Middle Income				
1980-1990	3.1	2.5	3.0	1.1

1991-2001	3.0	2.7	3.1	1.0
2002-2011	4.2	4.8	2.4	0.7
1980-2011	3.4	3.3	2.9	0.9
Upper Middle Income				
1980-1990	4.6	3.6	3.1	2.1
1991-2001	3.7	3.5	3.2	0.8
2002-2011	3.9	4.7	2.4	0.7
1980-2011	4.1	3.9	2.9	1.2
Sub-Saharan-Africa				
1980-1990	2.7	2.5	2.9	1.2
1991-2001	2.9	2.3	3.0	0.9
2002-2011	4.5	4.3	2.8	0.8
1980-2011	3.3	3.0	2.9	1.0

Table 8. Sub-Saharan Africa: Sources of per capita Real GDP Growth by Country, 1980-2011 (Alpha = 0.4)

	Per capita GDP Growth	Capital Deepening	TFP
SSA	0.8	0.2	0.6
Angola	1.7	0.1	1.6
Benin	0.8	-0.1	1.0
Botswana	4.2	1.7	2.4
Burkina Faso	1.9	1.3	0.5
Burundi	-0.1	0.4	-0.5
Cameroon	-0.7	0.0	-0.7
Cape Verde	3.3	1.1	2.2
Central African Republic	-0.9	-0.9	0.1

Chad	3.2	0.8	2.4
Comoros	-1.1	-0.6	-0.5
Congo	0.7	0.7	0.1
C™te d'Ivoire	-1.8	-1.1	-0.7
Democratic Republic of the Congo	-2.5	-0.1	-2.4
Equatorial Guinea	9.9	5.9	4.0
Ethiopia	1.9	0.1	1.8
Gabon	-0.6	-0.5	-0.1
Gambia	0.5	0.7	-0.2
Ghana	1.1	-0.6	1.6
Guinea	0.4	0.9	-0.5
Guinea-Bissau	0.1	-0.6	0.7
Kenya	0.4	0.1	0.3
Lesotho	2.3	1.6	0.7
Liberia	-0.9	-1.4	0.5
Madagascar	-1.4	-0.5	-0.9
Malawi	0.6	-0.3	0.9
Mali	1.6	0.5	1.2
Mauritania	-0.4	0.2	-0.6
Mauritius	3.3	0.9	2.4
Mozambique	2.3	0.5	1.7
Namibia	-0.5	-0.1	-0.4
Niger	-1.8	-1.3	-0.6
Nigeria	1.2	-0.5	1.7
Rwanda	1.7	1.1	0.6
Senegal	0.2	-0.2	0.4
Sierra Leone	-0.4	-0.4	-0.1
South Africa	-0.5	0.0	-0.5
Sudan	2.2	2.2	0.0
Swaziland	1.3	-0.3	1.7
Togo	-1.6	-0.9	-0.7
Uganda	2.7	1.1	1.6
United Republic of Tanzania: Mainland	1.5	0.1	1.5
Zambia	0.0	-0.5	0.5
Zimbabwe	-1.1	-1.1	-0.1

Table 9. Sub-Saharan Africa: Sources of per capita Real GDP Growth by Country with human capital data, 1980-2011

(Alpha = 0.4)

	Per capita GDP Growth	Capital Deepening	Human Capital Accumulation	TFP
SSA	0.5	0.1	0.6	-0.2
Benin	0.8	-0.1	0.8	0.2
Botswana	4.2	1.7	1.2	1.2

Burundi	-0.1	0.4	0.5	-1.0
Cameroon	-0.6	0.0	0.7	-1.3
Central African Republic	-0.9	-0.9	0.5	-0.5
Congo	0.7	0.7	0.4	-0.3
C™te d'Ivoire	-1.4	-1.2	0.6	-0.8
Democratic Republic of the Congo	-2.6	-0.1	0.4	-2.8
Gabon	-0.6	-0.5	0.9	-1.1
Gambia	0.5	0.7	0.7	-0.9
Ghana	1.2	-0.5	0.5	1.3
Kenya	0.4	0.1	0.6	-0.3
Lesotho	2.3	1.6	0.5	0.2
Liberia	-0.9	-1.4	0.7	-0.2
Malawi	0.4	-0.3	0.6	0.2
Mali	1.9	0.5	0.5	1.0
Mauritania	-0.4	0.2	0.6	-1.1
Mauritius	3.3	0.9	0.5	1.9
Mozambique	2.3	0.6	0.2	1.5
Namibia	-0.5	-0.1	0.2	-0.6
Niger	-1.7	-1.3	0.3	-0.7
Rwanda	1.7	1.1	0.6	0.0
Senegal	0.4	-0.2	0.5	0.0
Sierra Leone	-0.4	-0.4	0.5	-0.6
South Africa	-0.6	0.0	0.6	-1.3
Sudan	2.3	2.3	0.5	-0.5
Swaziland	1.3	-0.3	0.6	1.0
Togo	-1.6	-0.9	0.7	-1.4
Uganda	2.9	1.1	0.7	1.1
United Rep. of Tanzania: Mainland	1.6	0.1	0.5	1.0
Zambia	0.0	-0.5	0.5	0.0
Zimbabwe	-1.4	-1.1	0.8	-1.1

Table 10 SSA: Sources of per capita GDP Growth, by Sub-Group of Countries, with unadjusted labor, 1980-20011

(Alpha = 0.4)

	Per Capita GDP Growth	*Capital Deepening*	*TFP*
Low Income Countries			
1980-1990	-0.5	-0.1	-0.4
1991-2001	-0.2	-0.4	0.2
2002-2011	1.7	0.4	1.3
1980-2011	0.4	0.0	0.4

Lower Middle Income			
1980-1990	0.0	-0.1	0.1
1991-2001	0.2	-0.2	0.4
2002-2011	2.2	0.9	1.3
1980-2011	0.8	0.2	0.6
Upper Middle Income			
1980-1990	1.1	0.1	1.0
1991-2001	0.3	0.2	0.0
2002-2011	2.6	0.8	1.8
1980-2011	1.3	0.4	0.9
High Income Country			
1980-1990	-4.4	-0.8	-3.5
1991-2001	23.5	13.2	10.3
2002-2011	9.3	4.6	4.6
1980-2011	9.5	5.7	3.8
Sub-Saharan-Africa			
1980-1990	-0.2	-0.1	-0.1
1991-2001	0.5	0.1	0.4
2002-2011	2.2	0.7	1.4
1980-2011	0.8	0.2	0.6

Table. 11 SSA: Sources of per capita GDP Growth, by Sub-Group of Countries, with adjusted labor, 1980-20011

(Alpha = 0.4)

	Per Capita GDP Growth	*Capital Deepening*	*Human Capital Accumulation*	*TFP*
Low Income (16)				
1980-1990	-0.8	-0.3	0.6	-1.2

1991-2001	-0.3	-0.6	0.5	-0.4
2002-2011	1.7	0.4	0.6	0.9
1980-2011	0.1	-0.2	0.6	-0.3
Lower Middle Income(11)				
1980-1990	0.1	-0.3	0.6	-0.3
1991-2001	-0.1	-0.2	0.6	-0.5
2002-2011	1.8	1.4	0.4	0.4
1980-2011	0.6	0.3	0.6	-0.2
Upper Middle Income(5)				
1980-1990	1.5	0.3	1.2	0.1
1991-2001	0.5	0.1	0.5	-0.1
2002-2011	1.5	1.4	0.4	0.1
1980-2011	1.2	0.6	0.7	0.0
Sub-Saharan-Africa(32)				
1980-1990	-0.1	-0.2	0.7	-0.7
1991-2001	-0.1	-0.4	0.5	-0.4
2002-2011	1.7	0.9	0.5	0.6
1980-2011	0.4	0.1	0.6	-0.2

Figure 1

Growth of GDP and total factor productivity for Sub-Saharan-Africa: 1980-2011

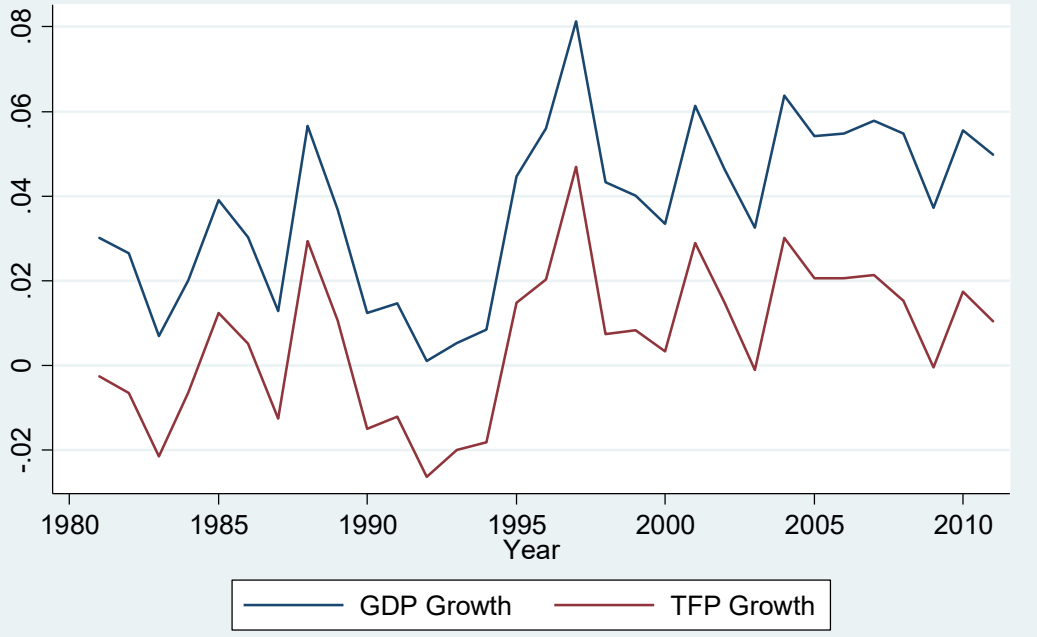


Figure 2

Employed Labor in SSA: 1980-2011

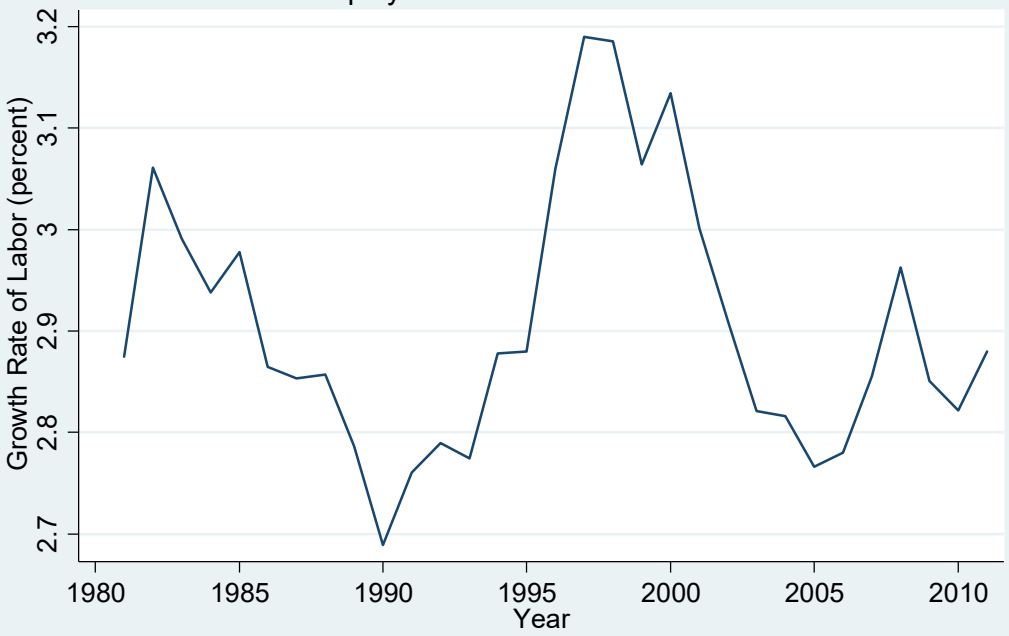
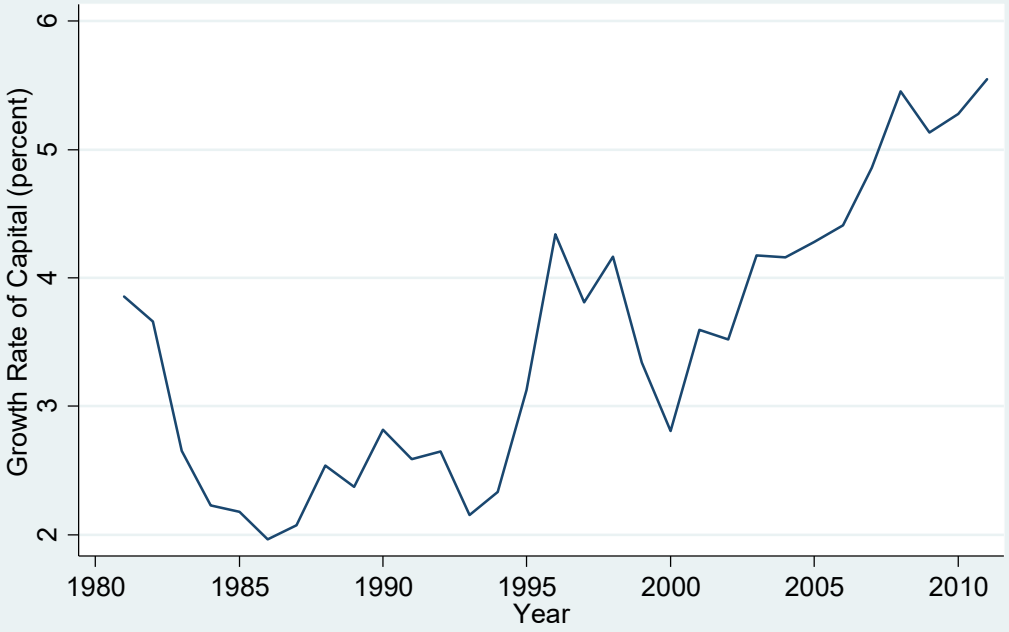


Figure 3

Capital in SSA: 1980-2011



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