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MALMQUIST INDEX DECOMPOSITION OF TOTAL FACTOR PRODUCTIVITY GROWTH IN SUB-SAHARAN AFRICA

Noah Alilu and Hyacinth Eme Ichoku
University of Nigeria, Nsukka, Nigeria

ABSTRACT

The Malmquist index approach was used for the estimation and decomposition of FP growth in 30 Sub-Sahara Africa economies with data obtained from Penn World Table 8.1 covering 1999-2014. Results reveals the total factor productivity decreased within the period, attributable to low technical efficiency and efficiency change (the catch-up effect) while mean of pure efficiency change deteriorated heavily to 0.983. However mean of technical change was positive at 1.030, implying that SSA economies are operating at below average, but potentially amenable to technological advancement. TFP growth recorded was due to technical progress especially innovation. hence a need for robust institutional reforms

Keywords:, TFP Growth, Malmquist Index & SSA.

1.0 Introduction

The analysis of the sources of growth, has received considerable attention in recent time. The recent controversy and debate has centered on whether the East Asian miracle was driven primarily by factor accumulation (capital and labor) or total factor productivity (TFP). The view that total factor productivity (TFP) plays a pivotal role in explaining overall economic growth could be traced back to the work of Abramovitz (1956), probably the first attempt to determine the sources of productivity growth. The author concluded that the main sources of U.S. productivity growth were still unidentified. This led Abramovitz (1956) to argue that the importance of TFP might be interpreted as some sort of measure of our ignorance about the causes of economic growth. Fifty years later, Caselli's (2005) still argues that most of the variation in income at the country level is explained by TFP. Solow (1957) proposed the existence of an exogenous residual capturing TFP. He also argued that cross-country differences in this exogenous residual (i.e. in TFP) might generate important cross-country differences in income per capita. Subsequent theoretical studies (e.g. Romer, 1990) provide alternative rationales for how TFP can endogenously explain economic growth.

TFP is defined as the portion of output not explained by the amount of inputs used in production. Its value represents how efficiently and intensely the inputs are utilized in production. The product decomposition exercise in this perspective is crucial to assess the contribution of each factor of production into the fall of growth and income inequality among the SSA economies. Understanding their roles in the evolution of growth and income per worker is crucial to guide economic policies aimed to foster growth and improve cross country income distribution.

For sub-Saharan Africa, while a number of papers have looked at the determinants of economic growth in the region (see Fosu, 2001 and Macphersop & Rakosvki, 2001), few have analyzed the sources of growth from a growth accounting perspective. The bulk of the analyses point to factor accumulation as the main source of growth in sub-Saharan Africa, with the contribution of TFP growth playing a minor role (see Onajala 2002: Subramaian & Roy, 2001: Akitoby, 2004 and Amin, 2002. This paper examines the sources of growth in sub-Saharan African countries, using the data envelopment analysis framework and extending the existing analysis both by country and time coverage. In this paper we try to determine the rate of productivity change and decompose the components into pure technical efficiency, efficiency change, and technical change as well as scale efficiency. We also try to ascertain the change in TFP, the signs and magnitudes of TFP change across SSA economies and the contributions of the efficiency components of productivity to TFP change in the sub-region.

2. Empirical Literature Review of Productivity Change and TFP Decomposition

Empirical evidence of what determines total factor productivity growth of nations is mixed. A research exposition from the perspective of TFP and capital accumulation on growth, Oleg Badunenko et'al (2013) employed data envelopment analysis (DEA) methods to construct the world production frontier, which was in turn used to decompose (labour) productivity growth into components attributable to technological change (shift of the production frontier), efficiency change (movements toward or away from the frontier), physical capital deepening, and human capital accumulation over the 1965–2007 period. Using this decomposition, they provided new finding on the causes of polarization (the emergence of bimodality) and divergence (increased variance) of the world productivity distribution. The study attributed the overall change in the distribution exclusively to physical capital accumulation, it equally found that technological change and human capital accumulation are also significant factors explaining the change in the distribution (most notably the emergence of a long right-hand tail). Robustness exercises indicate that these findings are attributable to the addition of (more recent) years and a much greater number of countries included in the sample than other studies in the past.

Rodrigo et'al (2007) used latent variable approach based on state –space model to estimate total factor productivity and it determinants in Chile. They argued that despite the important role that total factor productivity (TFP) has played in growth literature, few attempts have been made to change the methodology to estimate it. With this methodology it was possible to reduce the measurement of our ignorance as a by-product, this estimation yields the capital share in output and the long-term growth rate. When applied to Chile, the estimation shows a capital share around 0.5 and long term growth of TFP around 1%. Capital accumulation tends to explain more the growth rate in the fast growth periods under the econometric estimation compared to the traditional growth accounting methodology.

A similar study by Collins and Bosworth (1997) used growth accounting for a large set of countries in East Asia. The results of their analysis tend to indicate that positive TFP growth in East Asia was not particularly high when compared to that of other regions (although the interpretation of a low or a high residual is subjective). Like the other fundamentalists, they reach the conclusion that factor accumulation was more important and that aggregate production function included capital and the product of labour and education, hypothesizing that the benefits of education are labour augmenting.

Young (1995) regresseds the output growth rate per worker on a constant and the growth of capital per worker for the period 1970-1985 using cross-country data constructed from the Penn World Tables. The capital stock was constructed by the perpetual inventory method with the accumulating investment flows for 1960-1969 as benchmark, and a 6% depreciation rate. The results indicate that, while TFP growth in Hong Kong was relatively high, it was not out of the ordinary in South Korea and Taiwan, and very low in Singapore. Marti (1996) examines Young's (1994) results with slightly fewer countries but more periods than Young's data set, again using the Penn World Tables. She obtains a positive TFP contribution to the growth rate for Singapore, while her results for other East Asian high performers were roughly consistent with Young's.

Hall and Jones (1999) showed that differences in physical capital and human capital can only partly explain the variation in output per worker. They discovered that, large amount of variation in the level of the Solow residual can be found across countries. The differences in capital accumulation, productivity and output per worker are caused by differences in institutions and government policies, i.e., by social infrastructure. Social infrastructure was treated as endogenous factor in this research. Across 127 countries selected for this study, a powerful and close association was found between output per worker and measures of social infrastructure. Countries with long-standing policies are in favour of productive activities, rather than diversion, in order to produce much more output per worker. For example, their analysis suggested that the observed difference in social infrastructure between Niger and the United States is more than enough to explain the 35-fold difference in output per worker.

Ikemoto (1986) provides estimates of the TFP growth rate for 1970-1980 for several Asian economies using the Tornqvist index. He differentiates between the contributions of domestic and imported capital. His results indicate that productivity growth was positive in all economies considered. The contributions of TFP growth to overall growth in Taipei, China and Republic of Korea are very high. On the other hand, those of Hong Kong, China; Malaysia; Philippines; Singapore; and Thailand are much lower. Ikemoto indicates that in the cases of Hong Kong, China; Malaysia; and Singapore they already have a high level of technology, and thus it is more difficult to realize productivity gains. On the other hand, the Philippines and Thailand do not utilize enough the backlog of technological innovations. It is worth noting that in computing the input weights Ikemoto argues that, in the cases of Singapore, Philippines, Indonesia, and India, wage data did not seem to be reliable or did not exist, and therefore assumes the labour share to be 50 percent for Singapore, 60 percent for the Philippines and Indonesia, and 70 percent for India.

On the Contribution of TFP Components to Growth**,** Sangho et'al (2010) applied a stochastic frontier production model to data from 53 countries covering 1991-2003 to estimate total factor productivity growth, and to decompose it into technical efficiency change and technical progress. The empirical results indicates that world productivity was led by fast-growing newly emerging economies, whereas most developed countries experienced a decrease in productivity growth. Technical efficiency change significantly contributed to economic growth for many fast-growing countries, even though emerging economies still lag far behind developed countries in terms of technical efficiency.

Immaculada et'al (2011) analysed TFP growth in the EU for the main sector of private activity and decomposed productivity gains into technical progress (innovation) and efficiency (catching-up) by means of Malmquist indices. A dynamic model was equally estimated by system – Generalized Method of Moment (GMM) exploiting the panel structure of the dataset and taking into account unobserved country-specific effects and the possible endogeneity of the explanatory variables. In spite of the sectorial differences in TFP growth, the results show that all sectors experienced shifts in their frontier due to innovation with an enhancement of their catching up capabilities. It also indicates the importance of the sector structure in explaining productivity, and public and human capitals are found to be major contributors to TFP growth.

XU-Donglan (2006) employs data envelopment analysis (DEA) to analyse TFP, technological progress and efficiency change in Chinese manufacturing production from 1993-2002. The Malmquist (1953) productivity index was used to decompose into technical change index and efficiency change index which identified the contribution of the improved efficiency or technological progress in the Chinese manufacturing productivity growth. The results show that TFP in Chinese manufacturing sector grow annually by 2.4 per cent on average during the period 1994-2002, while the technical efficiency was 0.3 per cent. It indicates that TFP growth in Chinese manufacturing sector is mostly attributable to technological progress although efficiency improved during the period.

Chemingui et al (2007b) undertake the TFP growth analysis with a decomposition of it components into change in technical efficiency and technical change. Results show that

within the past four decades, average annual change in technical efficiency has been positive and sufficient to outweigh the negative contribution of technical progress, thus, on balance, leading to positive TFP growth for the period as a whole. However, the role of TFP growth for overall growth diminished over the time, with Morocco having lost ground relative to the world technology frontier.

Helmut et'al (2001) examine productivity change over about two decades for 32 Least Developed Countries (LDCs) and discovered an overall decline in total factor productivity (TFP), attributable to technology as a major problem area in LDC growth. Behind such decline, there was best-practice regress, indicating severe problems with the access to as well as the adoption of new technology. At the same time, technical efficiency in the group as a whole appears to have at least not declined to the same extent as LDC best practice, leaving some room for positive developments at individual-country level.

Ammara and Talat (2008) employ DEA approach and the Malmquist productivity index to explaining the East Asian growth miracle, the total factor productivity of eight East Asian countries over the period 1980-2000. The comparison of the sample countries reveals that Malaysian and Indonesian defined the frontier while South Korea caught up with the frontier countries in later years. Based on a panel regression with random effects of countries over the period, secondary education was the only variable that had a positive impact on TFP and efficiency growth while it was insignificants in technical change. On the contrary, trade openness and foreign direct investment were seen to be inconsequent as determinants of TFP growth and its component.

From the perspective on the Share of Capital and Labour in Output, Konstantinos et'al (2014) used a parametric decomposition framework of labour productivity growth and relaxing the assumption of labour-specific efficiency, with the updated Penn World Tables and Barro and

Lee (A new data set of educational attainment in the world 1950–2010 to a sample of 121 developed and developing countries during the 1970–2007. The measurement of labour efficiency is based on Kopp's orthogonal non-radial index of factor-specific efficiency modified in a parametric frontier framework. The empirical results indicate that the weighted average annual rate of labour productivity growth was 1.239 % over the period analysed. Technical change was found to be the driving force of labour productivity, while improvements in human capital and factor intensities account for the 19.5 and 12.4 % of that productivity growth, respectively. Finally, labour efficiency improvements contributed by 9.8 % to measured labour productivity growth.

In the same vein, Senhadji (2000), while using the same sample, estimates the share of capital for individual countries and for different regions by applying the Fully Modified estimator in levels and first differences. The estimated shares for physical capital by regions were as follows: East Asia 0.48, South Asia 0.56, Latin America 0.52, Middle East and North Africa 0.63 and Sub-Saharan Africa 0.43. In a study on the sources of growth in ten Middle East and North African (MENA) countries over the period 1960-98, Abu-Qarn and Abu Bader (2006) estimate the long –run share of capital in output using cointegration (country specific) and panel data (region specific) methods. They find that the share of capital in the MENA countries is much higher than the conventional share of 0.3-0.4. Their analysis of the source of growth show that the role of TFP in determining economic growth is insignificant and negative in some of the MENA countries and that most of the growth was to the accumulation of factor inputs.

Loukoianova and Uigobvskaya (2004) extend the period used by Broeck and Koen but using the same elasticity's of output (0.3 and 0.7 assumed for labour and capital respectively) with respect to capital and labour for all transition countries. To the extent that capital share in output is underestimated, it is no surprise that the result in their paper shows that most of the decline in output in 1991-1997 and recovery in input in 1998-2002 are explained by the movement in TFP growth. A more recent study on sources of recent rapid growth in central and Eastern European countries (Schadler et al, 2006) also assume shares of 0.35 and 0.65 for capital and labour, respectively.

3. Data and Methodology

Data Sources;

We construct a non-balanced panel data set consisting of 30 SSA countries over the period 1999-2014. The output variable is GDP measured at constant prices (2005 US$). It is obtained by taking the real GDP per capita chain series (rgdpch) from Penn World Table (PWT) 8.0 and multiplying it by total population for each country. With respect to labor we use a proxy, the population of equivalent adults (peqa), obtained from PWT. These data are obtained indirectly from the PWT6.3, by performing calculation using three variables.

$$L = \frac{rgdpch}{rgdpeqa}.pop = \frac{GDP}{pop}.\frac{peqa}{GDP}.pop$$

where rgdpch is the real GDP per capita chain series (rgdpch), rgdpeqa is real GDP per equivalent adult and pop is population. Input data on capital (K) is the standardized capital stock in year 2005 purchasing power parity equally obtained from World Productivity Database (WPD). This capital is computed from gross capital formation. The data of these variables of 30 countries included in the dataset is available at “www.wpd.org/unido/data”.

Methodological Framework

The theoretical specification of data envelopment analysis is as contained in this section. Below are the empirical models specifications

The production technology is defined as the set of all feasible input-output combinations. The production technology T in period t $T_0^t(X^t,Y^t), t = 1, \dots \dots \dots .T$ (1)

Where X^t is a *K*-dimensional vector of nonnegative inputs

$, x^t \equiv x_1^t, , \dots \dots .x_k^t), y^t$ is an $M -$ dimensional vector of nonnegative outputs $y^t \equiv y_1^t, , \dots \dots .y_m^t)a$

And T^t is the production possibility set for all feasible input-output combinations in period *t*. The output distance function $D_0^t(X^t,Y^t)$ is measured as the distance of a vector of inputs and outputs in period t with respect to the technical frontier in period t:

$D_0^t(X^t,Y^t)$=Min { >0 :(x^t, y^t/θ) ∈ }, t = 1… T, (2)

Where subscript *0* refers to output orientation in this study. The output distance function satisfies the inequality $D_0^t(X^t,Y^t)$≤1. $D_0^t(X^t,Y^t)$=1 indicates that the production unit is on the frontier of the production set and hence is technically efficient.

As earlier noted the Malmquist index measures the TFP change between two adjacent periods by calculating the ratio of the distance of each data point relative to a common technological frontier. Following Färe et al. (1994), the Malmquist index between period t and t + 1 based on the period t technology is given by

$$MI \ or \ TFP = \frac{D_0^t(X^{t+1},Y^{t+1})}{D_0^t(X^t,Y^t)} \qquad (3)$$

The Malmquist index can be greater than, equal to, or less than 1 if productivity grows, is stagnant, or declines between the two periods. Similarly, the Malmquist index between period t and t + 1 based on the period t + 1 technology is

$$MI \ or \ TFP_0^{t+1}(X^t,Y^t,X^{t+1},Y^{t+1}) = \frac{D_0^{t+1}(X^{t+1},Y^{t+1})}{D_0^{t+1}(X^t,Y^t)} \qquad (4)$$

Measures of the productivity change between period t and t + 1 generally change if the reference technology is different. To avoid the arbitrary choice of reference technology, Färe et al. (1994) suggested a geometric mean of the two Malmquist indexes:

$$MI or\ TFP_0^{t+1}(X^t, Y^t, X^{t+1}, Y^{t+1}) = \left[\frac{D_0^t(X^{t+1}, Y^{t+1})}{D_0^t(X^t, Y^t)} X \frac{D_0^{t+1}(X^{t+1}, Y^{t+1})}{D_0^{t+1}(X^t, Y^t)}\right]^{\frac{1}{2}} \quad (5)$$

The last equation gives an interpretation that Malmquist index (MI) is geometric mean of two efficiency ratios: the first one being the efficiency change measured by the period one technology and the other, the efficiency change measured by the period two technology. As specified from the equation Malmquist index consists of four terms namely: $\delta^t(x_t, y_t)^t, \delta^{t+1}(x_t, y_t)^{t+1}, \delta^t(x_t, y_t)^{t+1}$ and $\delta^{t+1}(x_t, y_t)^t$. The first two are related to the measurement within the same time period with δ^t or δ^{t+1} while the last two are for inter-temporal comparison. (MI) > 1 indicates progress in the total factor productivity of the country from period 1 to 2, while (MI) =1 and (MI) < 1 respectively indicate the status quo and deterioration in total factor productivity.

Balk (2001) show that the Malmquist index can be decomposed into four components: primal technical change (TC), technical efficiency change (EC), scale efficiency change (SEC), and output-mix effect or technological change (TECH):

$$MI \text{ or } TFP = TECHCH.EFFCH.PEFFCH.SECH. \quad (6)$$

Starting from the technical efficiency change, give a two period analysis therefore, the

frontier one, in period one is denoted by $\emptyset_1 = \frac{\text{eff of } (x_t y_t)^t \text{ WRT Frontier 1}}{\text{eff of } (x_t x_t)^{t+1} \text{ WRT Frontier 2}} \equiv \frac{\delta^t (x_t y_t)^t}{\delta^{t+1} (x_t y_t)^{t+1}}$ while frontier two, period two is denoted by $\emptyset_2 = \frac{\text{eff of } (x_t y_t)^{t+1} \text{ WRT Frontier 1}}{\text{eff of } (x_t x_t)^{t+1} \text{ WRT Frontier 2}} \equiv \frac{\delta^{t+1} (x_t y_t)^{t+1}}{\delta^{t+1} (x_t y_t)^{t+1}}$ And the entire period frontier –Shift therefore $\emptyset_1 X \emptyset_2 \equiv \frac{\delta^t (x_t y_t)^t}{\delta^{t+1} (x_r y_r)^{t+1}} X \frac{\delta^{t+1} (x_t y_t)^{t+1}}{\delta^{t+1} (x_r y_r)^{t+1}}$

Hence frontier shift $(F_c) = \sqrt{\emptyset_1 \emptyset_2}$ as their geometric mean

This is finally gives $TECHCH = [\frac{\delta^t (x_t y_t)^t}{\delta^{t+1} (x_r y_r)^{t+1}} X \frac{\delta^{t+1} (x_t y_t)^{t+1}}{\delta^{t+1} (x_r y_r)^{t+1}}]^{\frac{1}{2}}$ = frontier shift effect (7)

The magnitude of the first term, TECHCH, in general depends on the particular input-output combination. There is technical progress when TECHCH is greater than 1 and technical regress when it is less than 1. If TECHCH (X^{t+1}, Y^{t+1})=TECHCH (X^t, Y^t), the technical change is output neutral.

The technical efficiency, $D_0^t(X^t,Y^t)$, measures the distance of the firm's position in period t relative to the period t frontier of the technology, or how far the observed production is from maximum potential production. By definition TE≤1, and the production unit is efficient if and only if TE=1. That is (Frontier - shift) > 1 indicates progress in the frontier technology around specific country from period 1 to 2, while (Frontier - shift) =1 and (Frontier - shift) < 1 respectively indicate the status quo and regress in frontier technology.

EFFCH $\frac{D_0^{t+1}(X^{t+1},Y^{t+1})}{D_0^{t+1}(X^t,Y^t)}$ =catch up effect --------------------------------.8

The second term, EC, measures technical efficiency change between period t and t + 1. If EFFCH is greater than 1, the production unit moves closer to the frontier—in other words, the production unit is catching up to the production frontier by improving efficiency. A value of less than 1 indicates efficiency regress.

Scale Efficiency $SECH] = \left[\frac{S_0^t(X^{t+1},Y^t)}{S_0^t(X^t,Y^t)} X \frac{S_0^{t+1}(X^{t+1},Y^{t+1})}{S_0^{t+1}(X^t,Y^{t+1})}\right]^{\frac{1}{2}}$----------------.9

The third term, SEC, refers to scale efficiency change between two periods, which measures how the output-oriented scale efficiency changes over time conditional on a certain output mix. It is the ratio of the output-orientated measure of scale efficiency (OSE) in period t and t + 1, where

$SCE(X^t,Y^t) = \frac{D_0^t(X^t,Y^t)}{D_0^t(X^t,Y^t)}$ And $D_0^t(X^t,Y^t)$ is the output distance function based on the cone technology $T^t = \{(\lambda X^t,\lambda Y^t)|(X^t,Y^t) \in T^t,\lambda > 0\}$

If SCE = 1, the frontier point that can be reached by proportionally expanding yt is a point of technically optimal scale. At that point, the technology exhibits constant returns to scale and scale elasticity equals 1: $\in_0^t (X^t,Y^t)$=1. If SEC is greater than 1, the output bundle at period t + 1 lies closer to the point of the technically optimal than the output bundle at period t and

thus scale efficiency improves. If SEC is less than 1, the scale efficiency deteriorates.

The fourth term is labeled the output-mix effect, which measures how the distance of the frontier point to the frontier of the cone technology changes when the output mix changes, where the cone technology is the technology generated from the underlying observed technology.

Pure Technical Efficiency Change [PEFFCH] = $\left[\frac{TEC_0^t(x^{t+1},y^{t+1})}{TEC_0^t(x^{t+1},y^t)} X \frac{TEC_0^{t+1}(x^t,y^{t+1})}{TEC_0^{t+1}(x^t,y^t)}\right]^{\frac{1}{2}}$---------.10

That is, PEFFCH gives the change improvement in management practices and in the output-oriented scale efficiency from a change in the output mix when inputs remain constant. When the output mix changes, the scale efficiency increases if PEFFCH is greater than 1, and scale efficiency declines if PEFFCH is less than 1. In the case of a single output, PEFFCH = 1. Under global constant returns to scale technology, both SECH and PEFFCH are identically equal to 1.

Following Farel et al (1994) Malmquist index of productivity change period **t** (period one) and **t+1** (period two) is defined as,

MI = $\frac{\delta^{t+1}(x_t,y_t)^{t+1}}{\delta^t(x_t,y_t)^t} . \left[\frac{\delta^t(x_t,y_t)^t}{\delta^{t+1}(x_t,y_t)^{t+1}} X \frac{\delta^{t+1}(x_t,y_t)^{t+1}}{\delta^{t+1}(x_t,y_t)^{t+1}}\right]^{\frac{1}{2}}$ -----------------------------.11

The above equation represents the productivity of the production point (x_{t+1}, y_{t+1}) relative to the production (x_t, y_t). This index uses period **t** technology and the other period t+1 technology. TFP growth is the geometric mean of two output-based Malmquist – TFP indices from period **t** to period **t+1**. A value greater than one will indicate a positive TFP growth from period t to t+1 while, a value lesser than one will indicate a decrease in TFP growth or performance relative to the previous year. The malmquist index of total factor productivity change (TFPCH) is the product of technical efficiency change (EFFCH) and technology change (TECHCH) as expressed (Cooper, et'al, 2007); Eff Change [CE] or Catch-Up = --.12

$\frac{\delta^{t+1}(x_t,y_t)^{t+1}}{\delta^t(x_t,y_t)^t}$

Tech Change [TC] = $\mathbf{F_C} = [\frac{\delta^t(x_t,y_t)^t}{\delta^{t+1}(x_r,y_r)^{t+1}} X \frac{\delta^{t+1}(x_t,y_t)^{t+1}}{\delta^{t+1}(x_r,y_r)^{t+1}}]^{\frac{1}{2}}$ ----------------.13

Malmquist Index [MI] = Catch-Up X $\mathbf{F_C}$ (this equation captures objective two)

(MI) > 1 indicates progress in the total factor productivity of the country from period 1 to 2, while (MI) =1 and (MI) < 1 respectively indicate the status quo and deterioration in total factor productivity.

For the decomposition of productivity into components attributable to pure technical efficiency, efficiency change [catch - up effect], technical change (frontier –shift or technology effect), scale efficiency and total factor productivity [TFP] change.

This can be obtained using the equation below:

$$MI\ or\ TFP = TECHCH.EFFCH.PEFFCH.SECH.$$

Where Technical efficiency change $\mathbf{TECHCH}] = [\frac{\delta^t(x_t,y_t)^t}{\delta^{t+1}(x_r,y_r)^{t+1}} X \frac{\delta^{t+1}(x_t,y_t)^{t+1}}{\delta^{t+1}(x_r,y_r)^{t+1}}]^{\frac{1}{2}}$ = frontier shift effect-------------.14

Efficiency Change [EFFCH] $\frac{D_0^{t+1}(X^{t+1},Y^{t+1})}{D_0^{t+1}(X^t,Y^t)}$ =catch up effect -------------------------.15

Scale Efficiency $SECH] = \left[\frac{S_0^t(X^{t+1},Y^t)}{S_0^t(X^t,Y^t)} X \frac{S_0^{t+1}(X^{t+1},Y^{t+1})}{S_0^{t+1}(X^t,Y^{t+1})}\right]^{\frac{1}{2}}$---------------------------------.16

And Pure Technical Efficiency Change [PEFFCH]= $\left[\frac{TEC_0^t(X^{t+1},Y^{t+1})}{TEC_0^t(X^{t+1},Y^t)} X \frac{TEC_0^{t+1}(X^t,Y^{t+1})}{TEC_0^{t+1}(X^t,Y^t)}\right]^{\frac{1}{2}}$-----.17

4: Empirical Results of Malmquist Index of Productivity Change and Decomposition Analysis

The preferred methodology is the Malmquist Total Factor Productivity Index (MPI), which allows the determination of five different indices namely, the productivity change (TFPCH), technological change (TECHCH), efficiency change (EFFCH), pure technical efficiency change (PEFFCH) and scale efficiency change (SECH) indices. This index uses period t technology and the other period t+1 technology. TFP growth is the geometric mean of two output based malmquist-TFP indices from period (t) to period (t+1). A value less than one indicates a decrease in TFP growth or performance relative to the previous year. Efficiency change (catch-up effect) measures the efficiency change between current (t) and next (t+1) period, while the technological change (innovation) captures the shift in frontier technology. Pure technical efficiency measures the management agility and input/output mix strategy in production, while scale efficiency emphasis on the scope of production via large and small-scale operation.

Table 1.Malmquist Productivity Index Annual Mean 1999-2014 of SSA

Year	Pure Efficiency Change [1]	Scale Efficiency Change [2]	Efficiency Change Catch-Up=[1]x[2] [3]	Technical Change [frontier-shift) [4]	TFP Change 5= [3]x[4]
1999-2000	0.961	1.02	0.981	0.922	0.904
2000-2001	0.873	0.916	0.799	1.18	0.943
2001-2002	1.095	0.963	1.054	0.944	0.995
2002-2003	1.08	0.945	0.952	0.974	0.927
2003-2004	0.981	1.06	1.04	0.991	1.03
2004-2005	0.835	1.1	0.919	1.084	0.996
2006-2007	1.194	0.899	1.074	0.934	1.003
2007-2008	1.032	1.032	1.067	0.964	1.029
2008-2009	0.909	1.045	0.949	0.922	0.942
2009-2010	0.955	0.886	0.846	1.252	1.059
2010-2011	0.918	1.047	0.961	1.001	0.962
2011-2012	0.985	0.978	0.963	1.031	0.994
2012-2013	0.967	0.985	0.968	1.202	0.996
2013-2014	0.977	0.956	0.934	1.045	0.976
Mean	0.983	0.99	0.967	1.03	0.983

Source: Authors' computation using DEA 2.1

Table 1.1 above gives the annual average of all the Malmquist components scores of the 30 countries for each year. The result of the entire period 1999-2013 has not been encouraging as total factor productivity [TFP] change was quite low due to poor contribution of pure technical efficiency change and the efficiency change (the catch-up effect). The mean of pure efficiency change and the catching-up effect deteriorated heavily over the period with annual mean of 0.983 and 0.967 respectively. Pure efficiency change recorded single digit improvement in 2001-2002, 2002-2003, 2006-2007 and 2007-2008 with 9%, 8%, 2% and 3% respectively. On the other hand, catch-up effect improved relatively in 2001-2002, 2003-2004, 2006-2007 and 2007-2008 with 5%, 4%, 7% and 7% respectively. However mean technical change over the period under review is positive with1.030. This implies that in general, although Sub-Saharan economies are operating at below its maximum potential, the sub-region is amenable to technological advancement. Sources reveal that Total Factor Productivity [TFP] growth was due to technical progress [frontier – shift]. It thus infers that the sub-region was able to cause shift in their frontier due to technological diffusion through adoption of available technological knowledge. But it must be noted that the growth index of only 1.030 (2%) reflects that level of technology in the region is still abysmally low and technological adaptation has still a lot of potential for improvement. The sub-region needs an enhancement in productivity based catching-up capability especially the effective use of human capital in the labour market; increase the number of skilled worker to operate a more sophisticated technology and the adoption of new technology.

Source: Authors' computation using DEA 2.1

Figure 1: Pure Technical Efficiency and Efficiency Change [catch-up] effect in SSA 1999-2014

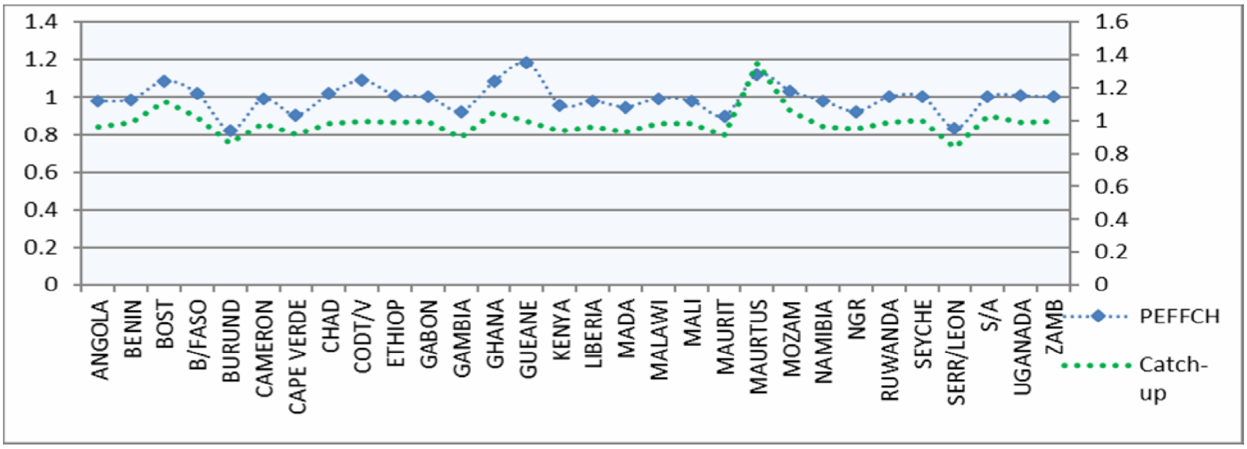
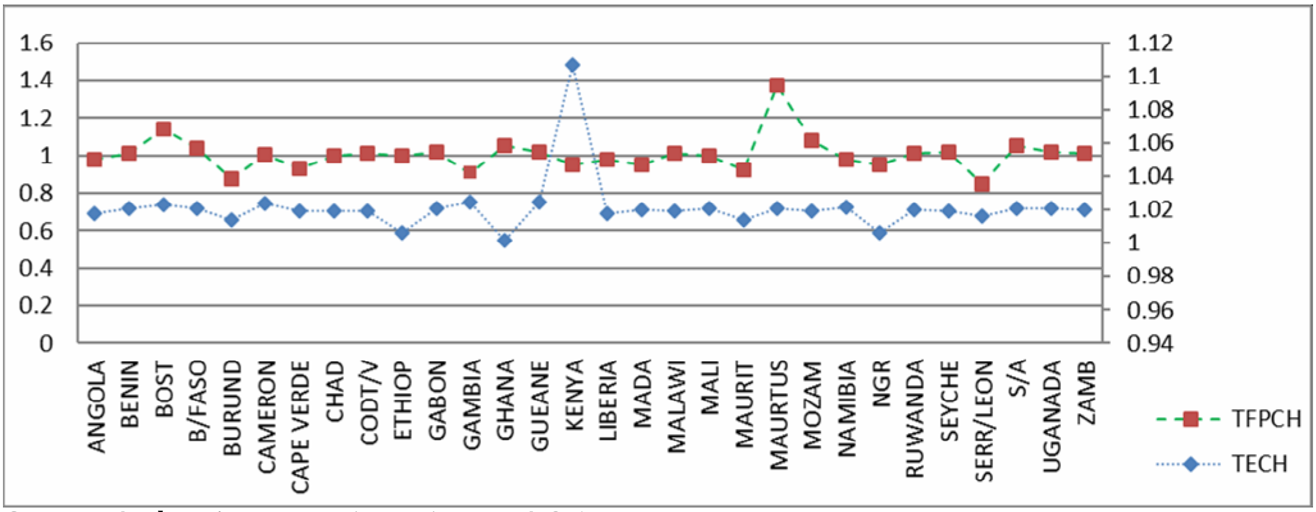


Figure 1 presents mean pure technical efficiency change and efficiency catch-up effect of the SSA countries over the 1999-2013 periods. In this period, pure technical efficiency change and catch – up effect fluctuated and decreased on average. Catch-up effect deteriorated significantly signaling a critical area of focus for attention if the sub-region must claim the 21st century and beyond.

Figure 2. Technological Change and TFP Change in SSA 1999-2014



Source: Authors' computation using DEA 2.1

Figure 2 presents the mean technological change and total factor productivity product [TFP] trend of the SSA economies in the study period. The average annual technological change was 1.030. That is, this period had a technical progress, on average. However, the TFP on average had 0.982. That is the period had deteriorated TFP performance generally. Evident from the graph, it was only Botswana, and Mauritius that cross the TFP frontier.

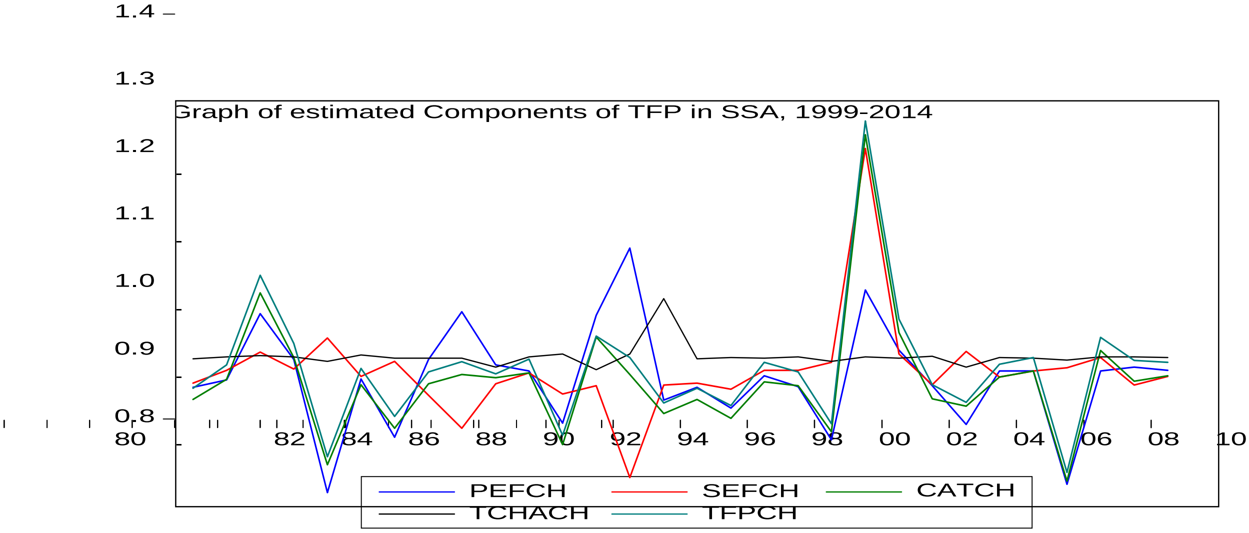
Table 2. Malmquist Productivity Index of the Selected SSA Country

Country	Pure Efficiency Change (PEFCH) [1]	Scale Efficiency Change (SEFCH) [2]	Efficiency Change (EFFCH) [Catch-Up Effect] [3]=[1]X[2]	Technological Change (TCHACH) [frontier-Shift] [4]	Total Factor Productivity Change (TFPCH) [5]=[3]X[4]
ANGOLA	0.976	0.982	0.958	1.018	0.975
BENIN	0.987	1.001	0.988	1.021	1.009
BOST	1.085	1.028	1.116	1.023	1.142
B/FASO	1.017	1.003	1.02	1.021	1.041
BURUND	0.82	1.049	0.861	1.014	0.873
CAMERON	0.988	0.992	0.98	1.024	1.004
CAPE VERDE	0.902	1.014	0.915	1.019	0.933
CHAD	1.017	0.964	0.981	1.019	0.999
CODT/V	1.088	0.915	0.995	1.019	1.014
ETHIOP	1.009	0.981	0.99	1.006	0.996
GABON	1	0.997	0.997	1.021	1.018
GAMBIA	0.923	0.966	0.891	1.025	0.905
GHANA	1.083	0.978	1.05	1.002	1.052
GUEANE	1.182	0.842	0.995	1.025	1.02
KENYA	0.957	0.979	0.937	1.107	0.953
LIBERIA	0.976	0.982	0.958	1.018	0.975
MADA	0.945	0.973	0.93	1.02	0.949
MALAWI	0.993	1.001	0.984	1.019	1.013
MALI	0.977	1.001	0.978	1.021	0.999
MAURIT	0.898	1.013	0.91	1.014	0.922
MAURTUS	1.12	1.33	1.35	1.021	1.371
MOZAM	1.031	1.025	1.057	1.019	1.077
NAMIBIA	0.978	0.98	0.959	1.022	0.98
NGR	0.921	1.029	0.948	1.006	0.954
RUWANDA	1	0.991	0.991	1.02	1.01
SEYCHE	1	1	1	1.019	1.02
SERR/LEON	0.832	1.005	0.837	1.016	0.85
S/A	1	1.02	1.03	1.021	1.05
UGANADA	1.006	0.979	0.985	1.021	1.016
ZAMB	1.001	0.992	0.993	1.02	1.013
	0.828	1.027	0.851	1.02	0.868

Source: Authors' computation using DEA 2.1

Table 2 indicates the annual averages of efficiency levels for all countries, which are given in column 2-5 of the Table. Evidently out of the 30 SSA countries, 15 recorded improvements in the total factor productivity with Mauritius and Botswana leading with double-digit growth index of 37% and 14% respectively. Others are with low single digit growth. Those that appear to be efficient along with these two are Burkina Faso, Rwanda, South Africa, Seychelles, Gabon, Namibia, Kenya, Angola, Ghana, Cameroun, Cote, d'Ivoir, Cape Verde and Zambia. Out of them South Africa, Seychelles and Rwanda are relatively outstanding with 7 and 5 percent TFP growth respectively. On the other hand, Serra-Leon appears to be the least efficient countries, followed by Burundi.

Figure 3: **Productivity Decomposition in SSA 1999-2014**



Source: Authors' computation using DEA 2.1

Figure 3 above shows the productivity decomposition. The decomposition of productivity of components attributable to pure technical efficiency, efficiency change [catch up effect], technical change (movement towards or away from the frontier) and total factor productivity change [TFP] is shown above. Obviously technological change [frontier shift] constant return to scale [CRS], which is innovative oriented, performed better than the rest components. Meaning that the sub-region still have the potential to improve technologically while eagle eyes must be on the rest components if they have to compete globally as frontier shift out-performed other components.

6.0 Conclusion

From the Malmquist Index result it is realized that the TFP growth is important because it determines the real standard of living that a country can achieve for its citizens. There is a simple link between productivity growth and the standard of living (Deliktas and Balcilar 2005).

After concisely presenting the disaggregated results for each country and year, we turn to a summary analysis performance of each country over the entire 1999-2013 time periods. If the value of the Malmquist index or any of its components is less than 1, it denotes retrogression or deterioration in performance, whereas values greater than 1 denote improvements in the relevant performance. These measures capture performance relative to the best practice in the sample, where best practice represents global frontier, and the global frontier is defined as the countries in the sample. Looking at the middle of Table **7**, we see that, on average, total factor productivity increased slightly over the 2004-2008 period for the countries in the sample: the average change in the Malmquist productivity index was greater than 1 percent per year for the sample as a whole. (Subtracting 1 from the number reported in the table gives average increase or decrease per annum for the relevant time period and relevant performance measure). On average, growth was due to innovation (TECHCH) rather than improvements in efficiency (EFFCH). Turning to the country-by-country results, we note that Mauritius has the highest total factor productivity change in the sample at 37% percent per year on average, almost half of which is due to improvements in efficiency. In fact, Mauritius's rate of efficiency change was the highest in the sample (i.e., Mauritius was especially good at moving toward the frontier or catching up). Also based on the constant-returns-to-scale (CRS) technology Botswana, South Africa and Seychelles's total factor productivity change was slightly higher than the sample average of 0.892. All of which was due to innovation or technical change.

Essentially, the average result with respect to technical change was suggestive and does allow us to identify which countries are shifting the frontier over time as virtually all the SSA Countries do. The technical-change component of the Malm-quist index tells us what happened to the frontier at the input level and mix of each country, but not whether that country actually caused the frontier to shift. In order to provide evidence as to which countries were the innovators, we look at the component distance functions in the technical change index. Specifically worthy of note however, all the 30 SSA countries estimates show TEFFCH>1 meaning that country innovation has contributed to a shift in the frontier between period t and t + 1 (1999-2013).

The results of this study demonstrate important issues. First is the discovery of the component that triggers TFP growth. For instance, Mauritius and Botswana had most of their productivity growth on account of changes in technical efficiency. In some countries despite the fact that the average of technical change was quite low, yet due to the relatively high efficiency changes, productivity growth has been positive. In other words, efficiency changes have been the main factor of productivity growth in these countries. It implies that we can increase TFP if efficiency of the component is improved.

In terms of technical change, even though it is low in 50% of the sample economies, it is quite significant in the rest 50% of the economies representing 15 countries. Countries such as Angola, Benin, Burundi, Cameron need to improve on their technical efficiency component. On the other hand, countries like Gabon, Chad, Guinea and Angola equally need to improve on the scale efficiency component. Even Namibia, Mauritius and Rwanda need to step-up the scale efficiency to improve the TFP growth. Although the technological change was catching to the frontier as exhibited in the table with 80% of the economies in that component, this could be the product of FDI and technology adoption by some SSA countries.

The efficiency change (catch-up effect) is another component that is obviously on a very low trend and thus, far from the frontier. Only three countries (Botswana, Seychelles and South Africa) representing 23% of the sampled economies performed creditably in this component. It implies that, 76.7% of the economies representing 27 economies need to improve in the efficiency change component to improve the TFP growth in their respective economies. However, since TFP growth is yield of two components, namely technical efficiency and technical change, these two components must be targeted to be on the path to sustainable growth.

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