Total Factor Productivity Convergence in Africa: Panel Unit Root Approach

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Abstract

The study tested absolute and conditional convergence of Total Factor Productivity in Africa using a sample of 23 countries and TFP data covering the period between 1960 and 2003 while deploying the panel unit root methodology. Countries that have experienced sustained economic growth rate are found to have invested in both factor accumulation and total factor productivity (technological progress). It has been argued that countries with similar technology and physical capital will converge if they share similar TFP. In this regard, this study aims at finding if there is total factor productivity convergence in Africa. The results show that there is evidence of conditional convergence and emergence of many convergence clubs of TFP in Africa. However, there is weak evidence of absolute convergence in Africa which is contrary to results obtained in developed economies. Based on the results, some recommendations were made.

Keywords: Total factor productivity, Convergence, Panel Unit Root.

1.0 Introduction

Sustainable economic growth and development has been found not to depend on capital accumulation but on Total Factor Productivity (TFP). In economic growth literature, labour and capital can be employed efficiently when there is adequate stock of technology in the economy. This assertion can be verified by the differing economic performance of country groups around the globe. In this context, economic performance is a function of technological progress which is generally referred to as total factor productivity. It is obvious that some countries are richer than others due to their disparate levels of economic growth which can either be measured in terms of GDP per capita or income per capita. While some studies focused on the factors responsible for growth, others focused on the factors that are responsible for the sustenance of growth. Solow [44] explained that differences in investment rate and population growth coupled with the differences in technology are responsible for the differences in income per capita across the countries of the world. Neoclassical exogenous growth model suggest that there is possibility of economic growth experienced by any country to decline given that diminishing returns to capital do set in over time. In this scenario, the growth experience becomes unsustainable as can be observed from some cross-country studies. Based on the Neoclassical exogenous growth model, economic growth and development can only be sustainable through technological progress. Modern endogenous theory of economic growth

pioneered by Romer and Lucas [42] shows that economies increase output through technological progress when they make deliberate investment in technology rather than assume that it is exogenous as contained in the neoclassical growth model. Empirical evidence in support of this fact has been controversial. While this seems to be the case for a group of OECD countries, it is not entirely true for the Asian and African economies [6] However, the neoclassical conclusion that in the long run, per capita growth rate across countries depends on total factor productivity (technological progress) in growth accounting models still remained a basis for the study of differences in economic performance.

Some regions of the world have experienced high growth rate because they converged in terms of total factor productivity. Several empirical studies reveal that highly industrialized economies share similar production functions due to spillover and diffusion of technology. It therefore became necessary to ascertain whether African countries converge or diverge in terms of technology. Barro and Sala-i-Martins, [5] described two basic concepts of convergence which are applied to the study of economic growth across countries or regions. The first is the concept of β-convergence (beta convergence). This type of convergence occurs if a poor country tends to grow faster than a rich country so that the poor country tends towards catching up with the rich country in terms of levels of per capita income or per capita product. The second type of convergence is σ-convergence (sigma convergence). This type of convergence occurs if the cross-sectional income dispersion measured by the standard deviation of the logarithm of per capita income or per capita product across a group of countries or regions declines over time. It has been argued that β-convergence leads to σ-convergence. In other words, σ-convergence cannot occur except there is β-convergence. However, notable growth economists argue that the existence of income dispersion may persist in spite of β-convergence due to new disturbances that tend to raise the income gap between the rich and poor countries. Similarly, there are two types of beta convergence in literature-absolute and conditional beta convergence. Absolute beta convergence exists when poorer countries tend to grow faster than the richer countries. This analysis is hinged on the fact that poorer countries can increase their income level with minimal effort since they are operating at a lower income level than high income level countries given that they share common technology and common saving rate. This catch up effect of poorer countries towards richer countries in terms of income, will take place with time irrespective of current income levels. On the other hand, conditional beta convergence exists when poorer countries tend to grow faster than than richer countries based on certain conditions. If the requisite conditions are not met, poorer countries will fail to grow faster the richer countries and therefore may not catch up. This condition may be in form of policies, institutional factors, population, stock of human capital and degree of openness of the economy in question.

This study therefore rests on the extant understanding of the two concepts of convergence as discussed above. Convergence studies on Africa concentrated on GDP per capita and income per capita convergence [36][37], O'Connell and Ndulu [37], Tahari, et al, [45]. The few studies which are available dwelt on TFP growth and determinants both within regions and within different sectors of an economy but not particularly on TFP convergence (Guetat and Serranito [16], Chaffai et al[10]. More so, none of these studies employed the

Panel unit root analysis to test for existence of convergence in Africa in terms of TFP. The study follows the methodology of Mishra et al [35] which found that countries that share the same socio-economic and macroeconomic fundamentals and which are located within the same geographical distance, converge. The aim of this paper therefore is to find out how this finding applies to a sample of African countries. Following Levin et al [27], this study assumes homogeneity of technology, same level of human capital stock, same level of physical capital and that there is similar degree of institutions, policy regulation, population and openness of the economy.

Nevertheless, the literature on TFP growth in Africa has been very sparse. The motivation of this work therefore is to obtain the TFP indexes for selected African countries and to test whether there is TFP convergence within Africa as this has been argued to be responsible for the regional growth of the OECD countries through technology diffusion and spillovers.

Conceptual Framework

Total factor productivity is conventionally seen as the increase in output growth that is not accounted for by factor inputs (capital and labor). Put differently, TFP is a measure of improvement in technology and efficiency in an economy (Kim and Lau, 1994). Economic historians have argued that long-term growth of an economy is to a great extent attributable to the growth of the TFP (technological progress) rather than growth in factor accumulation [28] [29].

Growth accounting model developed by Solow [44] is widely employed to explain what is meant by total factor productivity (TFP). Growth accounting is viewed as an empirical methodology that allows economic researchers to decompose the observed growth in GDP into different components that are associated with changes in factor inputs and in the production technologies (Barro and Sala-i-Martin, op cit). Because technological progress is difficult to measure directly with the growth rate of the GDP, economists resorted to taking the part of growth that is not accounted for by observable growth of inputs to be a measure of technological progress. That is, residual of growth not accounted for by capital and labor (given the interaction with other observable inputs). Even though this exercise can be extended to explain elements such as government policies, human capital, initial levels of physical capital and natural resources, growth accounting generally measures the fundamental determinants of economic growth without analyzing factors that drives the growth rate of each input or factor share. It is this growth residual that is referred to as total factor productivity.

Through the growth accounting model, output growth can be sustained via technological progress given the assumption of constant returns to scale and diminishing return of factor inputs. Countries that have experienced sustained growth over time are found to have pursued both growth in factor accumulation and growth in TFP which may represent some measure of labor efficiency in some instances [25] [26]. Even though there is general acknowledgement amongst economists of the influence of TFP on growth, there is lack of theoretical framework for the analysis of TFP [39]. This may be as a result of the divergent views with regard to the actual measurement of TFP.

Ozanne [38] pointed out that certain specification of TFP assumes that technical progress is disembodied and that it is equally possible to account for embodied technological progress which can either be labour-augmenting or capital-augmenting. A review of some of the growth accounting literature reveal that adjustments can be

made to the basic growth accounting equation in order to include human capital variable or labour quality variable. Mankiw et al [31] showed that the Solow [44] model can be augmented to include a measure of human capital index. Even though there is no consensus among economic scholars whether human capital should be treated as separate factor of production in growth accounting model, Islam [19] opined that human capital can influence growth through its effects on TFP. In this case, Knowles and Owen [25] suggest that human capital is labour-augmenting.

Some determinants of Total Factor Productivity include the degree of openness of an economy to international trade, the role of government in an economy, and the level of human capital in that economy, the role of FDI and the role of research and development (R&D).

2.0 African economic performance

Africa as a continent has generally recorded the poorest economic performance when compared with other regions of the world in the past three to four decades,[5],Njikam et al [36]. While other developing countries in Asia and Latin America are increasing in their economic growth rate, Africa has, at best stagnated with the countries having comparatively, the lowest GDP per capita. An overview of the African economy as a whole reveals that it consists mainly of primary production based on the extraction of raw materials.

Some of the reasons proffered for African backwardness stems partly from its turbulent history. Apart from colonization, there have been problems of corruption, despotism and attendant economic and political instability. Other factors that contributed to the slow pace of economic development in sub-Saharan Africa include low investment, low educational achievement, poor social infrastructure, poor policy choices and ethno-linguistic diversity which contributed to distorted foreign exchange markets and underdeveloped financial systems. Apart from a history of civil wars, there are equally prevalent climatic and geographical disasters with associated diseases and poor agricultural production. Some scholars argue that over-borrowing and poor debt management and over dependence on external aid, put Africa at risks of development. However, African capacity to achieve economic growth is stronger owing to the quick recovery from the global financial crisis. Economists observe that African economies` rate of recovery from the economic crisis was better than expected according to 2010 report. While the global GDP grew at 3.6 per cent in 2010 when compared to 2.1 percentage contraction in 2009, Africa`s aggregate GDP growth was 4.7 per cent in 2010 and has been forecast to rise up to 5.0 per cent in years to come. In spite of the above forecast, Africa still requires a significantly higher rate of growth to effectively tackle the problems of unemployment and poverty in the continent.

Some Empirical Results on TFP and Convergence

Baumol [6] showed that it was technological diffusion found in the industrialized economies that causes convergence. This line of argument centers on the spillover of technology from the leader economies to the followers that enhance catch-up and convergence. But this spillover was possible because the follower economies had the right type of economic environment that can accommodate the innovations which enables firms in that economy to leverage upon to remain competitive. Again, the right stock of human capital is needed in order to implement the innovation from spillover in the follower economy.

Aiyer and Feyer [4] made an analysis of the causal links between human capital accumulation and growth in TFP. They found out that human capital have a positive significant effect on the long -run growth of TFP. They showed that if there is high human capital intensity, there is the tendency of countries to benefit from R&D and new technologies through spillovers. So it requires the right type of human capital stock to take advantage of techniques produced elsewhere/off shore.

Miller and Upadhyay [34] studied the existence of convergence in TFP and GDP per worker across a pooled sample of 83 developing and developed countries using panel data that covers from 1960 to 1989. While testing for both absolute beta and sigma convergence with fixed effects, they found that there is both beta and sigma convergence in TFP.

Leonida et al [26] in their paper, investigated the regional convergence of the Italian economy. They argued that the idea of convergence of world economies can be extended to study regional economies within the same country. This line of argument is premised on the idea that convergence is possible because the different regions share similar economic fundamentals. This implies that there will be no need to control for the estimates of growth determinants within a regional framework. They used Malmquist productivity indices method to decompose the growth equation into technological progress and technical efficiency among the Italian regions and concluded that there is slow divergence among Italian regions.

Mishra et al [35] in their paper, showed that human capital accumulation enhance economic growth. They further presented the importance of convergence of TFP among countries that are neighbours as there is cross -border migration of skilled labour. They argue that there is interdependence of countries and that cooperation in growth policies promotes higher aggregate welfare due to similar socioeconomic characteristics. They opined that TFP of neighbouring economies is most likely to be correlated through migration and trade which equally promote spillover of knowledge.

Byrne et al [8] departed from the conventional sigma and beta test of convergence in cross-sectional regression analysis and adopted the time series framework in a panel of cross sectional data. The new method (Panel Unit Root) followed the work of Evans and Karras [15] They opined that the use of PUR will correct for the potential panel heterogeneity caused by differences in regional economic structure and differences in the growth path of each region while incorporating the potential cross sectional dependence occasioned by common shocks hitting the region at the same time. They made use of the growth accounting method according to Solow [44] to obtain a panel-varying TFP and employed Evans and Karras(1996) panel data method to test for convergence in TFP using a panel unit root test .The result show that the entire set of Italian region do not exhibit common process of convergence when Levin, Lin and Chu (LLC) test and Im,Pesaran and Shin (IPS) test are performed. However the multivariate augmented Dickey-fuller(by Sarno and Taylor) applied to the full panel, show that there is weak convergence. They conclude that there is no overall convergence in Italy but there is a process of convergence among subsets of regions.

Model specification and data sources

Drawing from the work done by Evans and Karras [15], the panel unit root is specified as follows:

Consider a sample of economies 1,2,….N assumed to have the same level of technological knowledge and a unique steady state for each economy in the sample;

if there is deviation of the state variables from its long-run values, it is going to be temporary and hence there are no effects on the long-run levels from the initial values of the state variables. The uniform technical knowledge conjecture by extension means that the balanced growth paths of the N economies are parallel (i.e, the state variables may only differ by constant amounts). On the other hand, there is divergence in the N economies if the deviations from the steady state are permanent. In other words, the initial values have effect in the long-run levels.

Evans and Karras [15] also show that economies converge in TFP if the following condition holds:

i. $\lim_{i\to\infty} E_t\left(tfp_{n,t+i} - \overline{tfp_{t+i}}\right) = \mu_n$ (1)

$$\Delta tfp_{it} = \alpha_i + \rho_i tfp_{i,t-1} + \sum_{z=1}^{p_i} \beta_{i,z} \Delta tfp_{i,t-1} + \varepsilon_{it} \quad (2)$$

where

$tfp_{n,t+i}$ = cross-country *TFP* growth rate $\overline{tfp_{t+i}}$ = country *i*`s *TFP* average growth rate

μ_n = cross-country *TFP* average

This means that the deviations of the respective tfp from their cross-economy average is possible and approach constant values as i approaches infinity. Therefore, there is unconditional convergence if, and only if, $\left(tfp_{n,t} - \overline{tfp}\right)$ exhibit higher growth rate than richer countries which shows occurrence of catching-up. Convergence then is said to be conditional if $\mu_n \neq 0$ for some n. In other words, each economy converges to its own steady state. Panel unit root test with fixed individual effects can be used to test for conditional convergence while absolute convergence can be tested with no individual effects. For this study, two types of panel unit root proposed by Levin et al [7] and Im et al [27] are applied. Levin et al [27] proposed a homogenous test with cross-sectional independence with individual effects and no time trend. Levin, Lin and Chu [7] [LLC] model is defined as follows:

for $i = 1, \ldots, N$ and $t = 1, \ldots, T$. $\varepsilon_{it} \sim i, id.$ The model tests the null hypothesis $H_0: \rho = 0$ against the alternative hypothesis $H_1: \rho = \rho_i < 0$ for all $i = 1, \ldots, N$ and assumes $\alpha_i = 0$ for $i = 1, \ldots, N$ under the null hypothesis with individual effects. The LLC test follows the adjusted t-statistic thus:

$$t_\rho^* = \frac{t_\rho}{\sigma_T^*} - NT\hat{S}_N\left(\frac{\hat{\sigma}_{\hat{\rho}}}{\hat{\sigma}_{\hat{\varepsilon}}^2}\right)\left(\frac{\mu_T^*}{\sigma_T^*}\right) \quad (3)$$

Im et al (2003) went a step further in their panel unit root test by recognizing that the sample members can be heterogeneous while assuming cross-sectional independence. Im, Pesaran and Shin [17] [IPS] is the same as LLC and defined their model with individual effects and no time trend as follows:

$$\Delta tfp_{it} = \alpha_i + \rho_i tfp_{i,t-1} + \sum_{z=1}^{p_i} \beta_{i,z} \Delta tfp_{i,t-1} + \varepsilon_{it}. \quad (4)$$

Accordingly, IPS test the null hypothesis, $H_0: \rho_i = 0$ for all $i = 1, \ldots, N$ while the alternative hypothesis is $H_1: \rho_i < 0$ for $i = 1, \ldots, N_1$ while $\rho_i = 0$ for all $i = N_1 + 1, \ldots N,$ with $0 < N_1 \leq N.$ IPS

show that the alternative hypothesis can contain unit roots for some of the individuals unlike LLC. Both tests make use of augmented Dickey-Fuller (ADF) unit root test but with specially adjusted t-statistics.

Our sample is made up of 23 African countries[1] with the data covering from 1960 to 2003. The study stopped at 2003 due to data unavailability on some selected countries. To obtain the TFP values, we made use of the standard growth accounting that defines TFP as output growth minus the growth of labour and capital. Following the work of Mishra et al (2008) we employed the Cobb-Douglas production technology and assume that the share of capital and labour are approximated as (1/3) and (2/3) respectively. We equally allowed constant returns to scale in the aggregate growth of all inputs together. Therefore, the TFP equation is

$$TFP_{it} = y_{it} - \frac{1}{3}k_{it} - \frac{2}{3}l_{it} \qquad (5)$$

Where TFP_{it} is the log of total factor productivity, y_{it} is used to denote log of real output, k_{it} and l_{it} represent log of the physical capital stock and log of the population respectively. Adopting the method of Klenow and Rodriguez-Clare [24], the physical capital stock of country i in period t satisfies

Table 1 List of countries in the sample

Benin	BEN	Mali	MALI
Burkina Faso	BURK	Mauritius	MAUS
Cameroun	CAM	Morocco	MORO
Chad	CHAD	Mozambique	MOZA
Cote d`ovire	COTE	Niger	NIGER
Egypt	EGY	Nigeria	NIGERIA
Gabon	GAB	South Africa	SAFRICA
Ghana	GHA	Togo	TOGO
Guinea	GUI	Uganda	UGAN
Kenya	KEN	Zambia	ZAM
Madagascar	MAD	Zimbabwe	ZIMB

$$K_{it} = \sum_{j=0}^{\infty}(1-\delta)^{t-j}I_{ij} + (1-\delta)^{t}K_{1960}. \qquad (6)$$

And the initial capital stock on the RHS is calculated by

$$\frac{K}{Y_{1960}} = \frac{I/Y}{\gamma+\delta+\eta}$$

Where (I/Y) is the average share of physical investment in output from1960 through to 2003, γ denotes average rate of output per capita over that period, η represents average rate of population growth over that period while δ represents the rate of depreciation, and it is set equal to 0.03. The real GDP per capita series which is measured in thousand constant dollars in 2001 international prices were obtained from the *Penn World Table Version 6.1* (Summer and Heston,2005).

Empirical Evidence

This work aims at finding if there is TFP convergence in Africa. It utilized the LLC and IPS panel unit root test of absolute (unconditional) and conditional convergence, for the purpose of analysis.

Panel unit root results

The panel unit root tests result presented in this study has been done bearing in mind, possible effects of heterogeneity. In this regard, individual fixed effects have been included both for LLC and IPS. It is worthwhile to mention here that the LLC imposes homogeneity for both null and alternative hypothesis where full convergence of the panel series is concluded if the panel unit root result is stationary or full non-convergence if the result shows presence of a unit root process (non-stationarity). The IPS test takes into consideration, heterogeneity and tests the alternative hypothesis that a fractional part of the series is stationary (conditional convergence in this case). Hence, LLC tests for absolute TFP convergence while the IPS tests for conditional TFP convergence. More so, convergence test through panel unit root can be performed without pair-wise or reference economy as used in some convergence literature. All the panel unit root results are obtained at 5% significant level where the Akaike Info criterion was used to select the lag length and automatic selection of Newey-West bandwidth and Bartlett Kernel parameters. Furthermore, results for both pooled panel and four (also five) year averages are presented.

Table 2 above shows the result for the full sample of countries in this study. As can easily be observed, there is no evidence of widespread absolute TFP convergence in Africa. The respective LLC statistics and p-values confirm that the pooled panel unit root tests are non-stationary and therefore there is no full convergence.

However, there is evidence of conditional convergence judging from IPS_2. The statistics is -1.81353 with a p-value of 0.0349 less than 0.05. In other words, some countries are converging to their own unique steady state in terms of TFP.

Table 3 panel unit root test for five - year average of TFP

All countries(N=23)

Test	Statistics	p-value	Conclusion
LLC_1	3.94681	1.000	No absolute convergence
LLC_2	-4.91333	0.000	Absolute convergence
LLC_3	-8.78809	0.000	Absolute convergence
IPS_1	-2.48915	0.0064	Conditional convergence
IPS_2	-1.02372	0.153	No conditional convergence

Table 3 presents the result of panel unit root test under five -year average of the time series. The results reveal that there is no absolute convergence when LLC_1 is applied. However, there is evidence of both absolute and conditional TFP convergence for LLC_2, LLC_3 and IPS_1 showing that African countries may be experiencing symmetric shocks and trends which bring about co-movement in their TFP and possibility of convergence in the long-run. Table 4 shows the results when the data is arranged in four-year average and produced results similar to Table 4 below. These reveal more evidence of TFP convergence than for the pooled panel result.

Table 4 panel unit root test for four- year average of TFP

All countries(N=23)			
Test	Statistics	p-value	Conclusion
LLC_1	3.7048	0.9999	No absolute convergence
LLC_2	-6.51331	0.000	Absolute convergence
LLC_3	-16.1401	0.000	Absolute convergence
IPS_1	-2.23587	0.0127	Conditional convergence
IPS_2	-1.12676	0.1299	

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Conclusion and Policy Recommendations

This study focused on Total Factor Productivity convergence in Africa. Following a generally accepted evidence of growth in per capita income and GDP attributed to growth in TFP and eventual growth of neighbouring countries, the study of economic growth convergence became very important in economics. For this purpose, forty four years TFP data spanning between 1960 and 2003 were used while applying panel unit root to test whether there is TFP convergence in Africa, or not.

The findings of this study are that there is no overwhelming evidence of unconditional TFP convergence in Africa as predicted by the exogenous growth theorists. This agrees with the findings of Njikam et al [36]. However, there is strong tendency towards TFP convergence when some other economic criteria are put into consideration. For example, most countries in Africa have come under military regimes and immature democracy such that there is perennial policy changes and poor policy implementation that affect efforts towards TFP growth. Similarly, poverty, corruption, diseases, wars and general insecurity had imparted negatively on the economic climate of Africa that only countries that are fairly stable recorded higher economic growth and hence TFP growth. As a result, there is more evidence of conditional TFP convergence in Africa as predicted by the endogenous growth theorists due to different

country-specific characteristics. In other words, some African countries converge to their own unique steady states.

There should therefore be deliberate efforts by policy makers in African countries to attract FDI as this has been proven to have positive impact of TFP growth through technology transfers. Even though there is a decrease in the amount of foreign aid to Africa, there should be judicious utilization of the much they receive to improve health and education which has direct correlation with TFP growth. Policy measures geared towards greater openness of African economies for the movement of both human capital and new technologies should be encouraged. It has been argued that international trade encourages TFP spillover through importation of goods embedded with recent technologies so that the recipient country can improve and therefore converge to the originators of such technology. More so, African countries need more specialized institutions where research for new technologies can be done as this will enhance factor efficiency in an economy. Finally, there should be purposeful actions towards the reduction of corruption, political instability and general improvement in security in order to encourage both local and foreign investors to come in. This will help to improve the growth of TFP and possible convergence within the African continent

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