# Determinants of Total Factor Productivity Growth in Africa

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***Abstract***

*The purpose of this paper is to investigate key determinants of Total Factor Productivity Growth (TFPG) in Africa. A panel of 41 countries from "all Africa" and 35 countries from Sub-Saharan were studied for the sample period 2002-2012. Panel data-based stationarity and cointegration analytical techniques were employed to assess data properties and to estimate the empirical model. TFP is estimated as a Solow residual from a production function specified in the framework of the augmented Solow growth hypothesis. The study found that factors such as inflation, domestic credit to the private sector, human capital and ICT are key determinants of TFPG per worker in Africa. For enhanced productivity growth in Africa, the study findings shed light towards policy direction of credit expansion to the private sector, extra investments in human capital stocks, expansion of ICT adoption and pursuance of price stability.*

**Key words:** Total Factor productivity growth, Panel data, Cointegration, Africa.

## Introduction

Total Factor Productivity (TFP) is a crucial measure of efficiency as well as technical change and thus, an important indicator for policy maker. TFP role in accelerating the pace of economic growth and increasing people's welfare is well recognized in literature. The view that TFP plays a pivotal role in explaining overall growth could be traced back to the work of Abramovitz (1956), who was the first author to attempt to study sources of productivity growth. A year later, Solow (1957) developed the first analytical framework for explaining existence of an exogenous residual. The Solow model identified technological progress or improvements in total TFP as the key determinant of growth in the long run (*ibid.*). The pivotal role of TFP in explaining growth was emphasized by subsequent studies (e.g., Lucas 1988; Romer, 1990 and Coelli & Rao, 2003), for example, Isaksson (2007) reports that growth in TFP provides society with an opportunity to increase in people's welfare. Comin and Mark (2006) point out that TFP remains important in growth theory because it does not only measure economic growth and cross-country growth differences but also economic fluctuations and business cycle frequencies. Caselli (2005) argues that in fact, most variations in incomes at country level are explained by TFP. Danquah, Enrique and Bazoumana (2012) report that TFP accounts for a sizable proportion of income differences across countries. TFP enhances an economy's ability to produce more output from a given stock

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of inputs. Higher TFP indicates better level of technology, higher per worker capital, and larger returns.

African pace of economic growth has been impressive in the recent past, especially after the year 2000. The Economist (2011) cites Africa to be a home to six of the world's ten fastest growing economies. World Bank statistics on development indicators show that Africa grew at a remarkable average rate of 5 percent from 2001 to 2010, while growth across Sub-Saharan Africa averaged 5.3 percent. In 2012, Sub-Saharan Africa's output expanded at a robust rate of 5 percent and 5.8 percent when South Africa, the region's largest economy by then is excluded (IMF, 2013) — a higher average growth rate than the developing country of 4.9 percent. Various drivers of African growth have been documented including, but not limited to commodities boom, favourable demography, enthusiasm for technology, especially in areas of Information and Communications Technology; Asian countries' penetration including China's surging demand for raw materials from the continent and higher commodity prices; encouraging cross-border commerce; pragmatic fiscal, monetary and external policies; economy diversification, rapid urbanization, expanding domestic demand; and a relatively increasing taste of peace as well as decent governments, among others.

As much as there is plenty of literature on Africa's growth performance with many authors documenting sources of Africa's impressive growth in recent decades, many studies have largely underscored the role of Total Factor Productivity in explaining Africa's growth process. Consequently, there is scanty literature on determinants of productivity growth in Africa. To authors who have used growth accounting to estimate TFP measure, there are concerns on treatment of panel data behaviour and tenacious ambiguities on precise measure of TFP. This study attempted to fill in gaps by operationalizing panel data multivariate linear regression analytical techniques that take into account stationarity and cointegration of the panel data variables. It utilized theoretical insights engrained in the augmented Solow growth model introduced by Mankiw, Romer and Weil (1992) to estimate a superior measure of technical change in order to better understand key determinants of TFP growth in Africa.

**Review of Related Literature**

Naanwaab and Yeboah (2013) examined determinants of multifactor productivity in a cross-country study of 33 African countries by focusing on the role of economic freedom and its sub-components as defined by the Heritage Foundation/Wall Street Journal Economic Freedom Index (EFI). Empirical results showed that economic freedom index (and most of its components) had positive and statistically significant impact on productivity of African nations (*ibid*.). Particular components of economic freedom that were found to be critically important on productivity include: business freedom, investment freedom, financial freedom, property rights freedom and freedom from corruption (*ibid*.). Similar findings on the role of economic freedom on productivity were reported by Bjørnskov and Ross (2010) in their study entitled "Do Economic Freedom and Entrepreneurship Impact Productivity?" Taking economic freedom to mean "institutions of liberty" measured by such variables as rule of law, easy regulations, low taxes and limited government interference, Bjørnskov and Ross (2010) found that these measures of economic freedom positively impacted on TFP.

Hammouda, Karingi, Njuguna and Jallab (2010) investigated the relationship among economic growth, productivity and diversification in Africa. Results from their study showed that deepening diversification leads to improvements in total factor productivity. The authors (*ibid.*) concluded that African countries can scale up their economies' growth by raising their total factor productivity through pursuing policies that enhance diversification. Using a panel of 28 Sub-Saharan African countries from 1965 to 1999, Razafimahefa (undated) conducted a study that investigated determinants of TFP in Sub-Saharan Africa. The author (*ibid.*) conducted the panel unit root tests following Levin, Lin and Chu (2002) method and employed a panel Granger causality test suggested by Hurlin and Venet (2001) to examine the relation between TFP and its determinants. His (*opt. cit.*) results showed that factors such as reallocation of resources from agricultural to non-agricultural sectors, agglomeration economies, infrastructural development and black market premium granger caused productivity. Wolf (2007) presented an empirical investigation of factors determining labour productivity growth in Africa. His (*ibid.*) study found that labour productivity is significantly affected by, among others, economic incentives index, education attainment, innovation and access to foreign technology through FDI. Democracy and infrastructure did not appear to significantly affect productivity (*ibid.*).

Isaksson and Ng (2006) discussed factors that inhibit TFP growth in selected African countries and showed that low investments in human capital, infrastructure, Research and Development (R&D) and weak institutions were major constraints to TFP growth on the continent. In a related study on how education affects productivity, Griliches (1970) analysed the case for the United States of America (US) from 1940 to 1970 and suggested that accumulation of education for the US labour force explained one-third of productivity growth measured with the Solow residual. Another related study was done by Hall and Jones (1999) to account for effect of education on productivity of the labour force using panel data on a total 127 countries, consisting of rich and poor countries. They (*ibid.*) constructed a measure of human capital based on estimates of return to education. They (*ibid.*) found that output per worker in the richest five countries was 31.7 times that in the poorest five countries. In a more recent study, Qutb (2017) conducted a study to examine the long run impact of education quality on TFP growth in Egypt from 1980 to 2014 and his study results revealed that TFP growth appeared to be significantly slightly enhanced by quality improvements in higher education only.

Akinlo (2005) did an exploratory study on effects of macroeconomic factors on TFP in 34 Sub-Saharan African countries for the period from 1980 to 2002. He (*ibid.*) used TFP estimates generated from production function that excluded human capital. The study results showed that factors such as external debt, inflation rate, agricultural value-added as a percentage of Gross Domestic Product (GDP), lending rate and local price deviation from purchasing power parity had a significant negative effect on TFP, whereas factors such as human capital, export to GDP ratio, credit to private sector as percentage of GDP, foreign direct investment as percentage of GDP, manufacturing value-added as a share of GDP and liquid liabilities as percentage of GDP had a significant positive effect on TFP (*ibid.*). Among macroeconomic factors, previous studies had reported similar results on how inflation affects TFP. For instance, Bitros and Panas (2001) using time series data for every two-digit Greek manufacturing industries found that inflation reduces TFP growth in a way, which is sizeable.

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Majority of existing literature on "determinants" of TFP face three main problems. Firstly, most existing studies use growth accounting method in the framework of the Solow (1956) growth model, which is based on estimation of a two-input Cobb-Douglas type production function. Secondly, only a few of known empirical works on determinants of TFP in Africa using panel data have undergone panel data stationarity diagnostics and panel cointegration tests prior to model estimation, a pattern, which casts doubt on plausibility of empirical results. Thirdly, a few studies that have attempted to investigate determinants of TFP in Africa have used numerous predictors of productivity, most of which their effects still remain an open issue with no unanimous conclusion. Using a more encompassing growth framework introduced by Mankiw, Romer and Weil (1992), the famous augmented Solow growth model, this study sought to find out key determinants of TFP growth in Africa by operationalizing panel data multivariate linear regression analytical techniques that take into account data properties of variables in the panel data setting.

**Methodology**

**Data and Data Sources**

The study utilized a balanced panel dataset consisting of 41 countries from "all Africa" and 35 countries from Sub-Saharan Africa over the period spanning from 2002 to 2012. Apart from computed data on TFP and TFPG, the data on rest of the variables used in the empirical model were obtained from the World Bank and OECD National accounts data bases, Barro-Lee data set and the International Monetary Fund (IMF) International Financial Statistics data files.

**Model Specification**

The study states a general panel multivariate linear regression equation with *m*- explanatory variables and *m*-parameters to be estimated with particular interest in variables that inhibit or enhance TFPG. Under these circumstances, the TFP equation to be estimated takes the following form:

$$tfpgw_{it} = \Theta + \sum_{j=n_k}^{m_k} \beta'_j X_{it-j} + Z_{it} \quad \ldots\ldots (1),$$

where *tfpgw* is total factor productivity growth per worker; $\Theta$ is a constant term; *k* represents the number of explanatory variables included in the empirical model; *t* is a time variable indicator; *i* is the country identifier; *j* represents the lags wherever applicable; $n_k$ and $m_k$ represent the range of lags; $\beta$ is a (k x 1)-dimensional vector of coefficients to be estimated; *X* is an (n x k)-dimensional vector of explanatory variables; and Z is the error term. Independent variables contained in the X-matrix include such variables as inflation (*inf*), lending rates (*lr*), financial deepening (*findeep)*, Net domestic credit (*domcred*), openness (*open*), external debt stocks (*extdebt*), population growth (*popg*), working age population (15-64) (*wkgpop_tpop*), human capital stock (*humcap*), rate of internet use (*internet*) and ICT goods imports (*ICTimp*).

**Measurement of Total Factor Productivity (TFP) and Total Factor Productivity Growth (TFPG)**

The study employed non-parametric growth accounting technique to estimate TFP. TFP was estimated as a technical change using the 'Solow residual.' Unlike many previous studies (including more recent studies, e.g., Qubt, 2017) who used a two-input production function to estimate TFP as a Solow residual from a production function and has been attached on grounds that it may suffer from measurement bias, this study attempted to minimize measurement bias in the TFP estimate by estimating a three-input production function based on augmented Solow growth hypothesis of Mankiw and colleagues (1992).

Consider a Hicks-Neutral production function of Cobb-Douglas type specified in the framework of the augmented Solow growth model:

$GDP_{it} = A(KF_{it})^{\alpha}(H_{it})^{\beta}(LB_{it})^{(1-\alpha-\beta)}$ ………………………….……….……….... (2);

where $A$ is a Hicks-neutral multifactor productivity (a measure of TFP); $GDP_{it}$ is Gross Domestic Product of country *i* at time *t*; $KF_{it}$ is 'Gross Capital formation' of country *i* at time *t*, which is used as a proxy variable for 'Capital stock;' $H_{it}$ is education attainment measured by the average years of total schooling of country *i* at time *t*, which was used in this study as a proxy for human capital; and $LB_{it}$ is the total economically active population; ages15+ (measured from the labour force participation rate relative to total working age population,ages15+) in country *i* at time *t*, which is used as a proxy variable for labour.

If data on variable "LB" are divided across terms in (2) and noting that A is a constant, an intensive form Cobb-Douglas production is obtained as:

$gdpw_{it} = A(kfw_{it})^{a}(hw_{it})^{b}$ ………………………………….……….....……….(3);

where $b = 1 - a$ under CRS assumption; *gdpw* is GDP per worker and *hw* is human capital per worker.

From intensive form production function in equation (3), an expression to measure TFP is derived as:

$tfpw_{it} = A = \dfrac{gdpw_{it}}{(kfw_{it})^{a}(hw_{it})^{b}}$ ……………………………………...……….….(4); where *tfpw* is Total Factor Productivity per worker.

Accordingly, equation (4) gives a measure of multifactor productivity per worker in the context of augmented Solow growth model, which is taken as a measure of technical change. This measure, as indicated in Equation 4, is obtained as output per worker divided by a weighted average per worker capital and labour inputs. Thus, multifactor productivity as provided by equation (4) measures changes in output per worker per unit of combined inputs of capital and labour. The data series on variables *gdpw*, *kfw* and *hw* were already available but parameters *a* and *b* were unknown and thus, data on *tfpw* were unavailable. Estimating the intensive form production function in (3) provided estimates for *a* and *b*, called input elasticities. Once values of these parameters are known, the annual series on *tfp w* were computed for each country using equation (4). Percentage changes in the variable *tfpw* from year to year were computed to give series on growth in *tfpw*.

**Diagnostic Tests**

The study conducted diagnostic tests on data behaviour of variables in the panel model and relationship behaviour between the variables in the model prior to regression estimation. On data behaviour, the study adopted the Harris–Tzavalis (HT) panel unit root test procedure to assess data stationarity on the premise that cross-sectional dimension (N) is larger than time dimension (T) for both country groupings considered in the study. On variable relationship behaviour, the study conducted panel model-based cointegration test using the Kao (1999) cointegration test methodology and implemented causality test suggested by Granger (1969) on a set of stacked data to ascertain nature of direction of causality between the suggested dependent variable and any of the predictors specified in empirical models.

**Estimation Techniques**

The OLS estimation procedure was used to estimate the translog intensive form production function in equation (3) for each country grouping on a set of pooled data to obtain input elasticities. On the other hand, the panel model in (1) was estimated using panel-data based cointegration estimation procedure of Fully Modified Ordinary Least Squares (FMOLS) upon finding cointegrating relationships and no endogenous regressors in the empirical model.

**Results**

**Estimates of the Input Elasticities**

Before estimation of a measure of TFP per worker by equation (4), researchers begun by estimating regression coefficients of production function for each country grouping. It was done in order to obtain estimates of marginal input elasticities or relative factor shares in total output. The study assumed identical aggregate production function for the set of countries in a particular country grouping, whose sample data were pooled as a single cross section. Therefore, the OLS method was used to estimate each country grouping production function as a linearized version of equation (3). Table 1 shows summary results of estimated input elasticities.

**Table 1: Summary of estimated output elasticities with respect to factor inputs**

| **Country groping** | **Estimated elasticity of *gdpw* with respect to *gkfw*** ($\hat{a}$) | **Estimated elasticity of *gdpw* with respect to *hw*** ($\hat{b}$) |
|---|---|---|
| "All Africa" | 0.77*** | 0.08** |
| Sub-Saharan Africa | 0.72*** | 0.10** |
| Diagnostic tests | Breusch-Pagan Chi-square stat.= 0.5623 | Breusch-Pagan Chi-square stat.= 0.4478 |

** & *** indicate that the coefficient is statistically significant at 5 and 1 percent respectively.

Regression estimates in Table 1 indicate that the share of physical capital per worker in total output per worker is 0.77 and 0.72 in production function for “all Africa” and Sub-Saharan Africa, respectively. On the other hand, estimates indicated that that the share of human capital per worker in total output per worker was 0.08 and 0.10 in the production function for “all Africa” and Sub-Saharan Africa, respectively. The Chi-square statistic from the Breusch-Pagan heteroscedasticity test did not reject the null hypothesis of homoscedastic residuals in the estimated production function for either country grouping at 10 percent significance level. Once the marginal input elasticities were estimated, authors proceeded to estimate TFP per worker series for each country belonging to a given country grouping using equation (4). From the estimates of TFP per worker, authors computed series for TFPG per worker of countries in a given country grouping. So, at this level, authors made observations on all variables in empirical (panel) model as specified in equation (1). We now proceed to estimate the empirical model in equation (1) which is in panel model setting. To estimate coefficients in the panel model we first check data behavior and variable relationships behaviour in empirical model by conducting stationarity tests, cointegration test and causality tests.

**Panel Unit Root Test Results on all Variables in the Empirical Models**
Test results on stationarity of all variables in the empirical model are presented in Table 2.

**Table 2: Summary of the panel unit root test results on model variables**

| | "All Africa" | | | Sub-Saharan Africa | | |
|---|---|---|---|---|---|---|
| **Variable** | Variable in level | Variable in first difference | | Variable in level | Variable in first difference | |
| | HT rho stat. | HT rho stat. | Order of Integration | HT rho stat. | HT rho stat. | Order of Integration |
| *Inf* | 0.4017*** | n/a | I (0) | 0.3012*** | n/a | I (0) |
| *Lr* | 0.8004 | 0.0478*** | I (I) | 0.8004 | 0.0485*** | I (I) |
| *findeep* | 0.0001*** | n/a | I (0) | 0.0000*** | n/a | I (0) |
| *domcred* | 0.8110 | 0.0150*** | I (I) | 0.7403 | -0.0090*** | I (I) |
| *open* | 0.4965*** | n/a | I (0) | 0.4826*** | n/a | I (0) |
| *extdebt* | 0.9414 | 0.0497*** | I (I) | 0.9421 | 0.0488*** | I (I) |
| *popg* | 0.9131 | 0.5799*** | I (I) | 0.8749 | 0.55597*** | I (I) |
| *wkage_tpop* | 0.8960 | 0.8467 | I (2) | 0.9418 | 0.7208 | I (2) |
| *humcap* | 0.8965 | 0.1760*** | I (I) | 0.8965 | 0.1409*** | I (I) |
| *internet* | 1.0590 | 0.1119*** | I (I) | 1.1515 | 0.3428*** | I (I) |
| *ICTimp* | 0.3199*** | n/a | I (0) | 0.3955*** | n/a | I (0) |
| *gtfpw* | -0.2099*** | n/a | I (0) | -0.2124*** | n/a | I (0) |

**, *** indicate that the statistic is statistically significant at 5 percent and 1 percent respectively

The panel unit root test results indicated in Table 2 show that for both country groupings, the rho statistic from Harris–Tzavalis (HT) unit root procedure rejects the null hypothesis of a unit root on variables: "*inf,*" "*findeep,*" "*open*" "*ICTimp*" and "*gtfpw*" at 1 percent significance level, suggesting that these variables are stationary in levels. It implies that the variables are integrated f order zero, I (0). On the other hand, for both "All Africa" and Sub-Saharan Africa equation specifications, the rho statistic from the Harris–Tzavalis (HT) unit root procedure does not reject the null hypothesis of a unit root in levels for variables: "*Lr,*" "*domcred,*" "*extdebt*" "*popg,*" "*popg,*" *humcap*" and "*internet*" at 10 percent significance level, while the statistic rejects the null hypothesis of a unit root in these variables in their respective first difference at 1 percent significance level. It implies that these variables are I(1). For the variable "*wkage_tpop,*" the rho statistic from the Harris–Tzavalis (HT) unit root procedure rejects the null hypothesis of a unit root in second difference, implying that the variable "*wkage_tpop*" is I (2).

**The Cointegration Test Results**

**Table 3: The Kao (1999) cointegration test results in the equation for determinants of TFPG in "All Africa"**

Null Hypothesis: No cointegration

| | t-Statistic | Prob. |
|---|---|---|
| ADF | -9.757002 | 0.0000 |
| Residual variance | 3774.244 | |
| HAC variance | 3406.504 | |

**Table 4: The Kao (1999) cointegration test results in the equation for determinants of TFPG in Sub-Saharan Africa**

Null Hypothesis: No cointegration

| | t-Statistic | Prob. |
|---|---|---|
| ADF | -8.997221 | 0.0000 |
| Residual variance | 4327.840 | |
| HAC variance | 3956.030 | |

As indicated in Table 3 and Table 4, the ADF t-statistic of the Kao (1999) cointegration test rejects the null hypothesis of no cointegration in the TFPG equations for both country groups at all conventional testing levels. Therefore, it is concluded from this test result that there is sufficient evidence of cointegrating relationships in the empirical model for determinants of TFPG specified for each country grouping.

**The Causality Test Results**

Table 5 summarizes, in terms of pair, causality test results based on the Granger (1969) causality test procedure. For panel data settings, the test was applied on a set of stacked data.

**Table 5: Causality test results in the empirical model**

| | **"All Africa"** | | **Sub-Saharan Africa** | |
|---|---|---|---|---|
| Null hypothesis | *Lag Order* | *F-Stat.* | *Lag Order* | *F-Stat.* |
| "*inf*" does not Granger Cause "g*tfpw*" | 4 | 2.20881* | 4 | 2.21159* |
| "g*tfpw*" does not Granger Cause "*inf*" | 4 | 0.19369 | 4 | 0.06125 |
| "*lr*" does not Granger Cause "g*tfpw*" | 4 | 1.98868* | 2 | 1.06056 |
| "g*tfpw*" does not Granger Cause "*lr*" | 4 | 0.27148 | 2 | 0.03387 |
| "*findeep*" does not Granger Cause "g*tfpw*" | 2 | 0.59825 | 4 | 2.88010** |

| | | | | |
|---|---|---|---|---|
| "gtfpw"does not Granger Cause "*findeep*" | 2 | 0.21766 | 4 | 0.09748 |
| "*domcred*" does not Granger Cause "g*tfpw*" | 2 | 0.29786 | 2 | 0.24494 |
| "g*tfpw*" does not Granger Cause "*domcred*" | 2 | 0.34233 | 2 | 0.10339 |
| "*open*" does not Granger Cause "g*tfpw*" | 2 | 0.62146 | 2 | 0.64430 |
| "g*tfpw*" does not Granger Cause "*open*" | 2 | 0.24814 | 2 | 0.05940 |
| "*extdebt*" does not Granger Cause "g*tfpw*" | 2 | 0.56508 | 2 | 0.66817 |
| "g*tfpw*" does not Granger Cause "*extdebt*" | 2 | 0.32148 | 2 | 0.47362 |
| "*popg*" does not Granger Cause "g*tfpw*" | 4 | 2.78973** | 4 | 2.16560* |
| "*gtfpw*" does not Granger Cause "*popg*" | 4 | 0.19178 | 4 | 0.13474 |
| "*wkgage_tpop*" does not Granger Cause "g*tfpw*" | 2 | 0.73809 | 2 | 0.61659 |
| "*gtfpw*" does not Granger Cause "*wkgage_tpop*" | 2 | 0.06648 | 2 | 0.04983 |
| "*humcap*" does not Granger Cause "g*tfpw*" | 3 | 0.07942 | 2 | 0.25509 |
| "*gtfpw*" does not Granger Cause "*humcap*" | 3 | 1.94146 | 2 | 1.91488 |
| "*internet*" does not Granger Cause "g*tfpw*" | 2 | 0.05223 | 2 | 0.03171 |
| "*gtfpw*" does not Granger Cause "internet" | 2 | 0.19718 | 2 | 0.07686 |
| "*ICTimp*" does not Granger Cause "g*tfpw*" | 2 | 0.49556 | 2 | 0.46396 |
| "*gtfpw*" does not Granger Cause "*ICTimp*" | 2 | 0.54934 | 2 | 0.62331 |

* & ** indicate that the statistic is statistically significant at 10 and 5 percent, respectively.

For the TFPG equation specified for "all Africa," the causality test results in Table 5 suggest the following:
The variables "*inf,*" "*lr*" and "*popg*" granger cause "*gtfpw*" at 10 percent significance level. The variables "*findeep,*" "*domcred,*" "*open,*" "*extdebt,*" "*wkage_tpop,*" "*humcap*" "*internet*" and "*ICTimp*" do not granger cause "*gtfpw*" at 10 percent significance level.

On the other hand, causality test results presented in Table 5 suggest the following for the TFPG equation specified for Sub-Saharan Africa:

The variables "*inf,*" "*findeep*" and "*popg*" granger cause "g*tfpw*" at 10 percent significance level.

The variables "*lr,*" "*domcred,*" "*open,*" "*extdebt,*" "*wkage_tpop,*" "*humcap,*" "*internet*" and "*ICTimp*" do not granger cause "*gtfpw*" at 10 percent significance level.

The general conclusion from the Granger causality test results indicated in Table 5 is that the test does not detect two-way granger causality between the dependent variable and any of the independent variables in the empirical models. This suggests that the empirical models should be estimated using single-equation estimation methods.

**Regression Estimates of the Empirical Model**
With evidence of cointegrating relationships in the empirical models for both country groupings and absence of two-way granger causality, the study adopted the single-equation panel data-based cointegration estimation technique to obtain the numerical coefficients of empirical models. In particular, the study implemented the Fully Modified OLS (FMOLS) estimation method.

**Table6: The Fully Modified OLS estimates of empirical models**

| Estimation Method: *Panel FMOLS*<br>Panel method: *Weighted estimation*<br>Cointegration deterministic: *cons*<br>Dependent variable*: gtfpw* | | |
|---|---|---|
| ***Indep. Variables*** | ***Equation specified for "All Africa"*** | ***Equation specified for Sub-Saharan Africa*** |
| | Coef. | Coef. |
| *inf* | -0.226781* | -0.477513* |
| lr | 0.434451 | 0.634451 |
| *findeep* | 0.000767 | 0.00207* |
| *popg* | -4.092152 | -7.136362* |
| *wkage_tpop* | 0.072108 | 0.232110 |
| *domcred* | 3.152891** | 6.616341*** |
| *open* | 1.109239 | 1.422899* |
| *extdebt* | -0.008911 | -0.014204 |
| *humcap* | 0.000206* | 0.004873 |
| *ICTimp* | 0.102624* | 0.270732** |
| *Other summary statistics* | $R^2 = 0.52094$; $\overline{R}^2 = 0.46789$<br>$\delta = 47.517446$ | $R^2 = 0.61318$; $\overline{R}^2 = 0.56247$<br>$\delta = 46.499$ |

*, ** & *** indicate that the statistic is statistically significant at 10, 5 and 1 percent respectively.

**Interpretation and Discussion of Model Estimates**

The authors first interpret and discuss results that are common to both country groupings and then proceed to interpret as well as discuss results that are unique to either country groupings and draw conclusion from such interpretation and discussion.

**A: Results Common to Both Country Groupings**

The role of inflation

For both "all Africa" and Sub-Saharan Africa, the model estimates in Table 6 indicate that coefficient on the variable "*inf*" is negative and statistically significant at 10 percent level. The implication of this result is that rising inflation is productivity inhibiting in Africa. Our study results in this aspect support the view advanced by Andres and Hernando (1997 who asserted that rising domestic prices is a constraint to productivity. This may be because price instability creates uncertainties in resource allocation, destabilizes planning and hence, it is detrimental to economic efficiency. The negative coefficient on inflation from empirical estimates of this study mirrors results from some other empirical studies, for instance, Akinlo (2005) who from his exploratory study on effects of macroeconomic factors on TFP in 34 Sub-Saharan African countries for the period from 1980 to 2002 reported that factors such as inflation rate had a significant negative effect on TFP.

**The impact of domestic credit**
In both "all Africa" and Sub-Saharan Africa, regression estimates in Table 6 indicate that estimated coefficient on the variable "*domcred*" is positive and statistically significant at 5 percent and 1 percent levels, respectively. Among all independent variables in the empirical model, results showed that the variable "*domcred*" has the largest statistically significant positive marginal effect of TFP per worker in the two country groupings, respectively. For instance, results showed that in Sub-Saharan Africa, a 1 percentage point annual increase in domestic credit to the private sector increases the long run growth in TFP per worker by approximately 6.6 percent, holding other factors constant. Therefore, results show that domestic credit expansion to the private sector is productivity enhancing for Africa. The positive and statistically significant coefficient on the variable "*domcred*" shows the importance of private sector participation in economic activity on enhancing productivity growth in Africa. Availability of private sector credit avails working capital, which promotes investment. Output per worker potentially increases from large economies of scale. Therefore, empirical results shade light on the role of private sector development on economic growth through improved productivity.

**The importance of ICT**
Model estimates indicate in Table 6 that the variable "*ICTimp*" is positive and statistically significant at 10 percent and 5 percent levels for "all Africa" Sub-Saharan Africa equation specification, respectively. Thus, results show that increasing proportions of ICT imports in total imports is productivity enhancing in Africa. This is likely to be so because a rise in ICT imports avails ICT infrastructure equipment including ICT technological diffusion, which are crucial elements of efficiency improvement.

**Factors that do not impact on productivity in Africa**
Model estimates from our study indicate that variables "*Lr,*" "*wkage_tpop*" and "*extdebt*" are statistically insignificant at 10 percent level for both "all Africa" and in Sub-Saharan Africa equation specifications. The implication of this result is that factors like lending rates (*Lr*), working age population as percentage of total population (*wkage_tpop*) and external debt stocks *(extdebt*) do not influence on TFP growth per worker in both "all Africa" and in Sub-Saharan Africa.

Although these variables display statistically insignificant coefficients, the positive sign on the variable "*Lr*" particularly draws our attention and extends our debate. The positive coefficient on lending rate here implies a positive association between lending rates and productivity growth per worker. This direction of relationship is rather unexpected but may as well be a crucial result that indicates behaviour of working individuals about working capital they obtain mainly from financial or lending institutions. Thus, the positive coefficient on lending rate implies that moderately increasing lending rates are productivity motivators. Probably this result means that in Africa, when individuals obtain financial capital from lending institutions at higher rates, they tend to be highly efficient in capital allocation, absorption and utilization, which then enhances their productivity. However, it is reasonable to say that unacceptably high lending rates should constrain productivity. The positive coefficient on lending rates from empirical results contradicts findings of some of the empirical researchers, for instance, Akinlo (2005) who found that lending rates had a significant negative effect on TFP in his empirical study on effect of macroeconomic factors on TFP in 34 African countries over the period from 1980 to 2002. The differences in results may possibly be due to the fact that Akinlo (2005) (i) estimated TFP excluding human capital, (ii) used an estimation technique different from one used in this study and (iii) used data over a different time period.

**B: Results Unique to Either Country Grouping**

**The contribution of human capital**

Model estimates in Table 6 show that the variable "*humcap*" is positive and statistically significant at 10 percent level in the equation for "all Africa" but with rather small marginal effect but the variable "*humcap*" is statistically insignificant in the equation for Sub-Saharan Africa though it remains positive. This result implies that while human capital development seems to be an important factor for TFP growth per worker in "all Africa," it is not particularly important for Sub-Saharan African productivity growth. Thus, extra investments in human capital may not raise productivity growth per worker in Sub-Saharan Africa but may have some positive marginal effects on productivity growth per worker in "all Africa" taken together as a continent. In either country groupings, the positive coefficient on human capital is plausible theoretically and is consistent with the findings from many other related studies. For instance, the role of human capital stocks or skills base stocks on productivity growth has been well documented by Wolff (2000). Our empirical results, to a large extent, agree with results obtained by Wolf (2007), whose study on empirical investigation of factors determining labour productivity growth in Africa revealed that labour productivity in Africa is significantly affected by education attainment, among other factors. There is also a theoretical postulate that high education attainment, skills acquisition and training enhance efficiency and hence, enhance productivity.

**The importance of financial deepening**

Regression estimates in Table 6 further show that the variable "*findeep*" is positive and statistically insignificant at 10 percent in the equation for "all Africa" but positive and statistically significant at 10 percent level in the equation specification for Sub-Saharan Africa. This shows that financial deepening is a key determinant of productivity growth per worker in Sub-Saharan Africa but is not for "all Africa".

**The role of population growth**

Regression estimates in Table 6 indicate that the estimated coefficient on the variable "*popg*" is negative for both "all Africa" and Sub-Saharan Africa. However, the coefficient is statistically significant at 10 percent level in the equation for Sub-Saharan Africa and statistically insignificant at 10 percent level in the equation for "all Africa." We find this result of particular interest with the implication that in Africa, in general, population growth is not an important factor of productivity growth per worker, though it seems to have a negative relationship with productivity growth per worker. Results, on the other hand, confirm that population growth is a constraint to productivity growth per worker in Sub-Saharan Africa. Results indicated that in Sub-Saharan Africa, a one (1) percent annual increase in population growth reduces growth in TFP per worker by approximately 7 percent, holding other factors constant. We find that the negative causal effect of population growth on productivity growth per worker in Sub-Saharan Africa and the negative relationship between population growth and productivity growth in "all Africa" reasonable. This is because increases in population growth particularly in Africa add on the consuming population rather than the productive population. Consequently, the ratio of the working population to total population reduces and thus, reduces output per worker.

**The importance of openness**

Regression estimates in Table 6 indicate that the variable "*open*" is positive and statistically significant at 10 percent level in the equation specification for Sub-Saharan Africa. On the other hand, the coefficient on "*open*" remains positive but statistically insignificant at 10 percent level in the equation specification for "all Africa." This result implies that increasing participation in cross-border trade is a key determinant of TFP per worker in Sub-Saharan Africa but necessarily so for "all Africa." Despite existing sceptical trade–productivity nexus in literature, we find that the positive causal effect of openness on productivity growth per worker in Sub-Saharan Africa and the positive relationship between openness and productivity growth per worker in "all Africa" is satisfactory. A number of previous studies on determinants of TFP have reported that countries that are more open in terms of international trade register higher productivity levels (see, for example, Yu, 2009; Danquah, Enrique & Ouattara, 2012). Our results provide empirical support to many previous studies.

**Explanatory power of the models**

The estimated regression model for "all Africa" provides approximately 47 percent goodness of fit (as measured by the adjusted coefficient of determination) of the regression line, while estimated regression model for Sub-Saharan Africa provides a higher explanatory ability of approximately 56 percent goodness of fit.

**Conclusion**

The study aimed at investigating key determinants of Total Factor Productivity Growth (TFPG) for Africa. Two country groupings were considered for the study: "all Africa" and Sub-Saharan Africa, where a total of 41 countries and 35 countries were studied, respectively. The country groupings are based on the cardinal classification of African countries according to the UN country groupings protocol. The study operationalized panel data-oriented cointegration estimation techniques. The cointegrating TFPG equations for both country groupings were estimated using the Fully Modified Ordinary Least Squares method (FMOLS).

Results showed that factors such as inflation, domestic credit to the private sector, ICT imports and human capital are key determinants of TFPG per worker in "all Africa," while factors such as financial deepening, inflation, domestic credit to the private sector, openness, ICT imports and population growth are key determinants of TFPG per worker in Sub-Saharan Africa. Estimates of the empirical model indicated that population growth has the largest negative causal effect on long run productivity growth per worker in Sub-Saharan Africa, while private sector credit has the largest positive causal effect on long run productivity growth per worker in both "all Africa" and Sub-Saharan Africa.

**Policy Implications**

The fundamental policy implications derived from this study include the following:

It is paramount for governments in Africa to ensure price stability in promoting productivity growth and hence, enhance economic growth. Central banks of African countries should exercise their rights of independence in tackling sources of macroeconomic disequilibria for purposes of ensuring good and enabling environment for economic agents do their business activities for enhanced production of goods and services without being constrained by unpredictable price volatilities. Credit expansion support services to the private sector seem to be strategic policy area that could enhance both productivity growth and economic growth in Africa. For instance, ease of access to credit to private sector with affordable terms increases the private sector participation in economic activity and this enhances productivity thereby economic growth. African governments should consider earmarking resources for extra investments in ICT infrastructure. More investments should be directed both in ICT technical infrastructure, which includes software, hardware and networks; and in ICT business infrastructure, which includes knowledge and skills in ICT management. ICT is fundamental among efficiency factors and therefore, increased ICT investments enhance both productivity and total production. It appears that increased investments in human capital by way of more investments in education and in skills acquisition as well as development enhance economic growth in "all Africa" (but not necessarily in Sub-Saharan Africa). Human capital development enhances technology diffusion, uptake and adaptation, which are important for productivity and growth.

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